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The at risk child: a contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.

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29/03/2021

To: The Editor-in-Chief, BMJ Paediatrics Open

Re: The at risk child: *A contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.*

Dear Professor Choonara,

We would like to submit an original research paper for your consideration in BMJ Paediatrics Open.

Trauma remains the leading cause of death for children in the UK, despite this limited data is available describing modern day injuries to children. Classical mechanisms of injury such as road traffic accidents have been greatly reduced in recent years following successful public health campaigns and government initiatives to improve road safety. An accurate understanding of how and where children are currently being injured is vital if we are to replicate this success and ensure we are effectively targeting our resources and safeguarding our future generations.

The current national trauma registry is limited by inclusion criteria designed for the adult population, as such it underrepresents the true burden of injuries to children as many will not meet these eligibility criteria. Of note, penetrating injuries are reported to affect just 2.2% of injured children nationally, however we have found this to be considerably higher in London and the South East, with almost 1 in 10 (9.6%) injured children being harmed by this mechanism. In fact, adolescents are now more likely to be injured by interpersonal violence than they are through a road traffic collision. By removing the eligibility restrictions placed on the national registry data and widening our lens we have been able to describe an accurate representation of the risks facing children across the London Major Trauma System (and potentially other urban settings in the UK).

The advancement in trauma care over the past decade has resulted in vastly improved survival for injured children reaching hospital. However, rates of safeguarding concerns and involvement of police and third sector organisations, such as violence reduction teams, are high (26.1%, 30.6% and 12.7% respectively). Understanding the contemporary risks facing children, and the unique challenges facing adolescents is vital to ensure effective safeguarding and prevention of injury.

As patterns of injury change, so must our approach to safeguarding. The traditional health-care practices of keeping children safe frequently relate to protection from caregivers. However, we demonstrate the importance of transforming our approach to safeguarding to reflect the additional contemporary risks of interpersonal violence and the prevention of avoidable harm.

We believe this work is important as it highlights the changing demographics of paediatric trauma and the importance of an accurate understanding of what puts modern day children at risk. Understanding this is vital of we are to effectively safeguard our future generations.

We present our manuscript for your consideration. The manuscript has been seen and approved by all authors. Additional supporting documentation detailing the role of authors has also been provided. We have recommended the following reviewers as requested and detailed their reason for choice below.

Mr Joe Curry, Consultant Paediatric Surgeon at Great Ormond Street Hospital, London, has been chosen due to his expertise in paediatric surgery and awareness of the impact of trauma in regions such as London and to provide a perspective from outside of the London Major Trauma System.

Mr Philip Hammond, Consultant Paediatric Surgeon at Royal Hospital for Sick Children, Edinburgh, has been chosen due to his expertise in paediatric surgery and interest in paediatric trauma and to provide a perspective from outside of the English Trauma Network System.

Dr Liz Hammond, Consultant in Paediatric Emergency Medicine at Hull University Teaching Hospitals, Hull, has been chosen due to her expertise in paediatric emergency medicine, paediatric trauma and child safeguarding and to provide a perspective from an urban area in the North of England.

Yours Sincerely,

Miss Ceri Elbourne MBBS, MRCS, PGCert Leadership for Health (Darzi)

Writing on behalf of the Paediatric Evaluation of the London Major Trauma System Collaborators

The at risk child: *a contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.*

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Required Statements

Transparency Declaration

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the evaluation being reported and that no important aspects of the study have been omitted.

Funding

No funding was received to undertake this evaluation.

Competing interest statement

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: organisational support (provision of online secure platform for data sharing, SLACK) was provided by the Healthy London Partnership; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Authorship/Contributorship

Authors role and responsibilities have been detailed on submission of this manuscript. This multi-centre evaluation was contributed to by many individuals who have been named in the collaborators/ non-author contributors list.

Patient and Public Involvement

Patient or public involvement was not possible in the production of this work.

Data Sharing

The collaborators will consider sharing of data if an appropriate request is made.

Dissemination Declaration:

Dissemination of the results to participants is not applicable.

Ethical Approval and Consent:

This project met the criteria of a service evaluation therefore ethical approval and patient consent were not required.

Collaborators (Non-Author Contributors):

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Abstract:

• **Background:** Injury is a leading health burden in children yet relatively little is reported about the contemporary risks they face. Current national registry data may underrepresent the true burden of injury to children. We aim to analyse contemporary patterns of paediatric trauma and identify current factors putting children at risk of injury.

• **Methods:** A three month prospective multi-centre cohort evaluation of injured children across the London Major Trauma System. All children receiving a trauma team activation; meeting NICE CT head criteria; or admitted/transferred out due to trauma were included. Data were collected on demographics, mechanism and location of injury, and body region injured. The primary outcome was in-hospital mortality and secondary outcome was safeguarding concerns.

• **Results:** 659 children were included. Young children were more likely to be injured at home (0-5 year olds: 70.8%, n=167 vs. adolescents: 15.6%, n=31). Adolescents were more likely to be injured in the street (42.7%, n=85). Head trauma caused over half of injuries in 0-5 year olds (51.9%, n=121). Falls were common and increasingly prevalent in younger children, causing 56.6% (n=372) of injuries. In adolescents, penetrating violence caused more than one in five injuries (21.9%, n=50). Most injured children survived (99.8%, n=658). However, one in four (26.1%, n=172) had safeguarding concerns and a quarter of adolescents had police, third sector, or external agency involvement (23.2%, n=53).

• **Conclusions:** This study describes changing demographics of modern day paediatric trauma and highlights the variance in injury patterns in young children and adolescents. Importantly it highlights differences in actual rates of injuries compared to those reported from current national registry data. We must understand real risks facing 21st century children to effectively safeguard future generations. The results provide an opportunity to reassess the current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

Introduction

Trauma remains the leading cause of death and morbidity for children.(1) Historically, road related incidents have been the greatest source of death and serious injury to children(1). Contemporary mechanisms of injury are evolving, with interpersonal violence(2,3) and falls(4,5) overtaking as the most common causes of injury in children. Effective safeguarding of children requires an accurate understanding of contemporary risk, this is essential to underpin future injury prevention strategies, if the success of those reducing road related children's casualties is to be replicated(6). As mechanisms of injury in children evolve, the focus of injury prevention processes must also adapt. Accurate understanding of modern day injury patterns is therefore essential to minimise risk and enhance child safety.

Falls, traditionally seen as a predominant cause of injury in the elderly, are now a leading mechanism of trauma in children.(4,5) Despite this, awareness of the burden of falls for children in the UK is limited(7), especially when compared to the falls prevention strategies seen in older people. Falls frequently result in head injuries in children, the impact of which is subject to a growing body of evidence detailing the cognitive and socio-economic impacts of even mild traumatic brain injury in early years.(16,17)

Contemporary reports also reveal a rise in violence related injury in both young adult(2) and paediatric populations(8,9), however current violence reduction strategies focus mainly on young adults.(3,10) In 2018 a single centre study in London found a penetrating injury rate of 9.4% in under 16s(2). Yet in the same year, national trauma data suggested that only 6% of injured children aged 16 or less suffered penetrating injuries in London.(11) These data may under-represent the true incidence of paediatric violence-related injury due to the volume of cases not currently meeting national registry inclusion criteria. Currently the contemporary risks, aetiology and demographics of paediatric injury is unknown. Accurate understanding of this is vital to ensure appropriately targeted, effective injury prevention strategies and safeguarding (11).

We aimed to characterise the incidence of trauma in children cared for within the London Major Trauma System (LMTS). The primary aim was to investigate the contemporary causes, risks and outcomes of injury for children in differing age cohorts. Secondly, we wished to evaluate safeguarding interventions associated with injured children.

Methods

A prospective paediatric trauma evaluation was carried out over a three-month period from February to April 2018. This time frame was chosen for consistency with previous trauma service evaluations within our system.(12,13) The LMTS serves a wide geographical region(14). All Major Trauma Centres (MTCs) and Trauma Units (TUs) within the LMTS were invited to take part in the evaluation and engagement was optimised through meetings with network leads and the pan London Paediatric Trauma group. Each site registered the evaluation with their local clinical audit teams and had a dedicated consultant clinical lead and data collectors. Anonymised data were collected by clinicians on injured children who met at least one of the following inclusion criteria:

- those who had a trauma team activation ('trauma call');

- those who were admitted or transferred out due to trauma;
- those who met NICE criteria for CT head due to trauma.

In view of the frequency of which children with minor injuries present to emergency departments the inclusion criteria were defined so as to identify the most severely injured children. Those with isolated minor injuries which did not require admission to hospital, advanced imaging or activate the hospitals trauma team response were not included. Patients were also excluded if they were found to have had a non-trauma cause for presentation or if their age exceeded the hospital's definition of a child. The definition of 'paediatric' varies across the system, therefore for this evaluation a child was defined as birth-16 years or birth-18 years as per individual hospital determination.

A case report form was completed for each patient. Data were collected on age, gender, mechanism of injury, location of injury, and injuries per body region. The primary outcome was in hospital mortality, secondary outcome was safeguarding concerns raised. Safeguarding children is defined by the UK government as *"preventing harm to children's health or development, taking action to enable all children and young people to have the best outcomes, to protect children from abuse and maltreatment and to ensure children grow up with the provision of safe and effective care."*(15) All children with safeguarding concerns raised were discussed in local psycho-social meetings as per local hospital policies and multidisciplinary team decisions were made regarding onward referral to social services and/or health visitor. Children were followed up until they were discharged from hospital.

Descriptive statistics were used to compare differences between age cohorts (0-5 years, 6-11 years, and greater than 12 years). These cohorts were chosen to reflect significant periods of child development: infancy, childhood, and adolescence. Continuous data are presented as medians with interquartile ranges. Categorical data are presented with percentages.

This project was conducted by clinical staff within each of the four trauma networks forming the LMTS and met the criteria of a service evaluation, therefore ethical approval was not required.

Results

During the three month study period 665 children were identified within the participating hospitals. Six were excluded due to age or non-trauma causes, leaving 659 children included in the evaluation. Of these, half (52%) were cared for in an MTC and nearly two thirds were male (64.6%) (Table 1). Whilst the median age was 8.9 years [Interquartile range: 3.75-13.96] a bimodal distribution of age was identified, with peaks of injury in the very young (0-2 years) and in adolescence (Figure 1A). The youngest cohort (0-5 years) was the largest (37%) followed by >12 years (35%) then those aged 6-11 years (28%) (Table 1).

Across the entire cohort, penetrating trauma accounted for 9.6% of injuries, however in adolescents, penetrating injury affected 1 in 5 (21.9%). The predominant blunt mechanism of injury was falls (56.5%). Road traffic collisions accounted for just 12.6% of injuries. Over a quarter of injured children

required an operative intervention (29.4%) and admission to intensive care was 3.3%. Mortality was very low (<1%), with one child dying in the youngest cohort (Table 1). Similarly, hospital length of stay for survivors was short at a median of one day (IQR 1-3).

Location of injury differed according to age (Figure 1B). In younger children aged 0-5 years, the majority were injured in their home (70.8%). Almost three quarters of these younger children had suffered a fall (74.7%), with more than half of this age group sustaining head injuries (51.9%) (Table 1). Conversely, adolescent injuries commonly occurred in the street and almost a quarter of this age group (22.8%) were injured through interpersonal violence. Once again head injuries predominated however abdomino-thoracic trauma was greatest in adolescents compared to other age groups (10% vs. <1%, Table 1). Polytrauma affected a tenth of the cohort (11.4%) (Table 1).

Safeguarding concerns were raised in 1 in 4 injured children (26.1%) (Table 2). These were identified in all age groups but bimodal peaks of concern were observed in the youngest (30.3%) and oldest children (33.3%) (Figure 2A). Overall, almost 1 in 3 children (30.6%) were referred to social services or the health visitor following their injury (Table 2). These referrals also followed a bimodal distribution, with highest peaks in the youngest and oldest cohorts (Figure 2B). Almost a quarter of adolescents required input from the police and third sector organisations (Table 2) with a stepwise increase observed from the age of 13 years onwards.

Discussion

This evaluation has characterised the contemporary incidence and mode of traumatic injury for children within the London Major Trauma System through a prospective evaluation of injured children presenting to a trauma system not selected by Injury Severity Score (ISS) or length of stay. This includes data captured for all children presenting with injury severe enough to require a trauma team activation, admission or transfer for ongoing care, and/or CT head. This data offers a complete overview of contemporary paediatric trauma within a region to date and helps to fill existing knowledge gaps, present due to the selection bias of the current national registry inclusion criteria. Data were captured from children managed in both MTC and TU settings across the LMTS, including both rural and inner-city populations, and use the same core methodology as previous trauma service evaluations.(12,13)

Variation exists in the pattern of injuries seen in childhood and adolescence. Differences were seen in the location of children's injuries, with preschool age children most likely to be injured in their homes compared to older children and adolescents, who were most likely to be injured in the street. Traditional mechanisms of trauma associated with children, such as road traffic collisions, were less evident, with falls being the primary cause of injury in the younger cohort whilst a demonstrable rise in interpersonal violence and penetrating injuries was observed in adolescence. Head injuries predominated across all age groups with over half of the younger children affected. The higher rate of abdomino-thoracic injuries seen in adolescents is thought to be associated with increased penetrating trauma in this group. A quarter of the children included in this evaluation had significant safeguarding concerns raised and one in four adolescents required input from police and/or third sector organisations. Mortality was low (0.2%) and this contrasts with previous reports of mortality at 8.8% in severely injured(12) and 3.1% in moderately injured children.(5) Whilst our cohort contained children of all injury severities, other factors such as the maturation of the trauma system are likely to have contributed to increased survival.(13)

This study highlights differences in how children and adolescents sustain traumatic injury. In our cohort, the predominant cause of injury in children was falling. This was greater in younger children, a group most at risk of injury in their home environment. Injury in the home is common and offers opportunity for injury prevention.(16) Children aged 0-5 years were most likely to suffer head injuries. Previous reports have suggested toddlers, aged 1-4 years, have the lowest rates of head injury, however such reports have limited their data to those children with moderate to severe injury.(5) By expanding our cohort, we highlight the risk of head injuries in this age group, most sustained as the result of unintentional falls. The consequences of falls in this age group, particularly those with mild traumatic brain injury, are increasingly appreciated, with evidence suggesting lasting cognitive effects for the individual and economic effects for society.(17,18) Understanding the true burden and the avoidable nature of these injuries makes head injury prevention a paediatric public health priority.

Interpersonal violence poses a serious risk to adolescents(2)(8) with one fifth sustaining injuries due to alleged assault, the vast majority of which were penetrating. This equates to one child every two days suffering penetrating injuries across our region. Reported rates of paediatric penetrating injuries have previously been much lower, 2.2%.(5) Our findings highlight how current national registry eligibility criteria may underestimate the reality of penetrating injury in children nationally as many will stay in hospital for less than three days or not require critical care admission. Accurate understanding of the true volume of these injuries is vital if we are to effectively target resources for injury prevention. Prevention strategies must recognise the involvement of younger children and capitalise on the potential for intervention in this group to break the cycle of children later presenting as young adults with life threatening injuries.

Safeguarding remains a major concern in contemporary paediatric trauma care. The need for safeguarding was raised in a quarter of the children and this was highest in both the youngest group and in adolescents. It is known that infants under one year are at the highest risk of non-accidental injury (NAI).(19) Educational programmes introduced to aid parents to develop strategies to cope with crying babies have been highlighted as important in reducing the risk of these youngest and most vulnerable children.(20–22) The bimodal distribution of safeguarding concerns also highlights the need to consider the unique safeguarding challenges faced by adolescents(23). Our findings question what effective modern day safeguarding in children and adolescents looks like. Safeguarding children has traditionally been viewed as a family experience, with support for caregivers being of paramount importance in preventing harm to children. The same view is not currently taken for children or adolescents as the victims of interpersonal violence. Historically effort has focused on the prevention and identification of NAI, often at the hands of caregivers.(24) Yet safeguarding practices must also reflect the contemporary risks of intentional interpersonal violence and the prevention of avoidable harm from unintentional injury which may impact a child's ability to reach their full potential. Early years interventions may be vital in reducing these risks(25).

This project has a number of limitations. Firstly, we were not able to capture any pre-hospital deaths which may have occurred in the three month evaluation period. Secondly, some of the smaller TUs were not able to participate due to service commitments therefore some cases will have been missed. However, each of the four major trauma centres participated, suggesting that the most severely injured children were included. The project ran for a period of three months, the time frame chosen in line with previous trauma service evaluations, therefore seasonal differences in

attendance may not be accounted for. Injury severity scores were not collected for all included children therefore overall analysis of injury severity was not possible. Finally, children whose injuries were not severe enough to meet the inclusion criteria were not included, and incorporation of these may have identified other patterns of injury which may yield further opportunities for injury prevention.

By expanding our lens, this evaluation has bridged a gap in the understanding of paediatric trauma, however many learning opportunities remain. Further research would ideally include a yearlong, nationwide study, to remove seasonal and geographical variation, with optimised case inclusion (all hospitals, all networks, pan-UK) to include data capture on pre-hospital deaths, emergency department discharges and longer-term outcomes.

Finally, injured children should not be thought of in isolation. Consideration must be given to the families and wider support networks which play a vital role in prevention and in rehabilitation. As such, opportunities for patient and family engagement in future work and co-development of injury prevention strategies must be at the forefront.

Conclusion

This study has described the changing demographics of modern day paediatric trauma and has highlighted the variance in injury patterns in young children and adolescents. Importantly it has highlighted differences in actual rates of injuries compared to those levels reported from current national registry data. The importance of a contemporary understanding of the real risks facing children in the 21st century cannot be underestimated if we are to safeguard our future generations effectively. The results provide an opportunity to reassess our current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

Key points/Summary box.

This study demonstrates three new major areas of concern in the injury of children.

1. Current national registry eligibility criteria underestimate the true incidence of paediatric injuries.
2. Interpersonal violence is a significant and currently underestimated cause of injury in adolescents.
3. Traditional understanding of safeguarding must be modernised in line with the contemporary risks facing children and adolescents.

What is known about this subject?

- Trauma is the leading cause of death in children
- Injury patterns vary across age groups
- Falls are the most common cause of injuries in under 5's

What does this work add?

- National registry criteria vastly underrepresents the true volume of paediatric trauma
- Prevalence of interpersonal violence in children and adolescents is significantly higher than previously reported
- Traditional approaches to safeguarding must be modernised to reflect contemporary risks of interpersonal violence and avoidable harm

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Ceri Elbourne: Chief investigator, project design, data collection, analysis, interpretation and write up, drafting and critically appraising work, final approval, accountability for work.

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Breda O'Neill: project design, data collection, analysis, interpretation and write up, drafting and critically appraising work, final approval, accountability for work.

Table 1: Demographics and injury characteristics

	All Children (n=659)	0-5 years (n=247)	6-11 years (n=184)	12+ years (n=228)
Male	426 (64.6)	145 (59.4)	114 (62)	167 (73.2)
Location of Injury				
Home	241 (40.5)	167 (70.8)	44 (27.5)	31 (15.6)
Street	152 (25.5)	21 (8.9)	46 (28.8)	85 (42.7)
School	98 (16.5)	16 (2.5)	45 (28.1)	37 (18.6)
Other	102 (17.1)	32 (13.6)	25 (15.6)	46 (23.1)
Mechanism of injury:				
Blunt	596 (90.4)	243 (98.3)	175 (95.1)	178 (78.1)
Penetrating	63 (9.6)	4 (1.7)	9 (4.9)	50 (21.9)
Fall	372 (56.5)	184 (74.7)	109 (59.2)	79 (34.6)
RTC	83 (12.6)	13 (5.3)	35 (19)	36 (15.8)
Assault	63 (9.5)	6 (2.4)	5 (2.7)	52 (22.8)
Blunt	22 (3.3)	6 (2.4)	4 (2.2)	12 (5.3)
Penetrating	41 (6.2)	0 (0)	1 (0.5)	40 (17.5)
Other*	139 (21.1)	43 (17.5)	35 (19)	61 (26.7)
Body region injured:				
Head	252 (39.6)	121 (51.9)	65 (36.1)	66 (29.5)
Upper limb	133 (20.9)	47 (20.2)	51 (28.3)	35 (15.6)
Lower Limb	113 (17.7)	26 (11.2)	35 (19.4)	52 (23.2)
Abdomino-thoracic	25 (3.9)	1 (0.4)	1 (0.5)	23 (10.3)
Pelvis	4 (1.7)	0 (0)	2 (1.1)	2 (0.9)
Spine	19 (8)	1 (0.4)	8 (4.4)	10 (4.5)
Soft tissue	26 (11)	17 (7.3)	2 (1.1)	7 (3.1)
Face	23 (9.7)	13 (5.6)	8 (4.4)	2 (0.9)
Polytrauma	27 (11.4)	2 (0.8)	5 (2.8)	20 (9.9)
Management:				
MTC level care	343 (52)	126 (51.0)	91 (49.5)	126 (55.3)
Required Surgery	194 (29.4)	50 (20.2)	72 (39.1)	72 (31.5)
Intensive Care Admission	22 (3.3)	5 (2.0)	7 (3.8)	10 (4.4)
Outcomes:				
In-hospital Mortality	1 (0.15)	1 (0.4)	0 (0)	0 (0)
Hospital stay (days)~	1 (1-3)	1.5 (1-2)	1 (1-4.5)	2 (1-5)

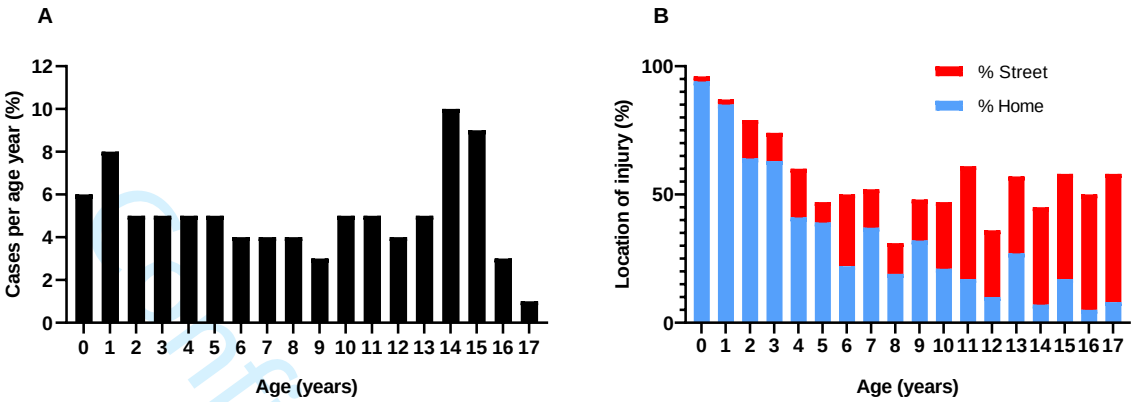
All data are presented as n(%) except for Hospital Stay (Median with Interquartile range)~.
RTC: Road Traffic Collision, *Other includes sports injury, burns, deliberate self-harm, MTC: Major Trauma Centre.
Denominator changes where data was missing: Mechanism of injury: n=658 (blunt vs penetrating n=659), 0-5yrs n=246. Location of injury: all n=595, 0-5yrs n=236, 6-12yrs n=160, 12+yrs n=199. Body region injured: all n=637, 0-5yrs n=233, 6-12yrs n=180, 12+yrs n=224.

Table 2: Safeguarding

	All Children (n=659)	0-5 years (n=247)	6-12 years (n=184)	12+ years (n=228)
Safeguarding concern	172 (26.1)	75 (30.4)	21 (11.4)	76 (33.3)
Referral to HV/SS	202 (30.6)	97 (39.3)	30 (16.3)	75 (32.9)
Police Involvement	84 (12.7)	13 (5.3)	18 (9.8)	53 (23.2)
3rd Sector/external agency involvement	61 (9.3)	4 (1.6)	4 (2.2)	53 (23.2)

All data are presented as n(%). HV: Health Visitor; SS: Social Services.

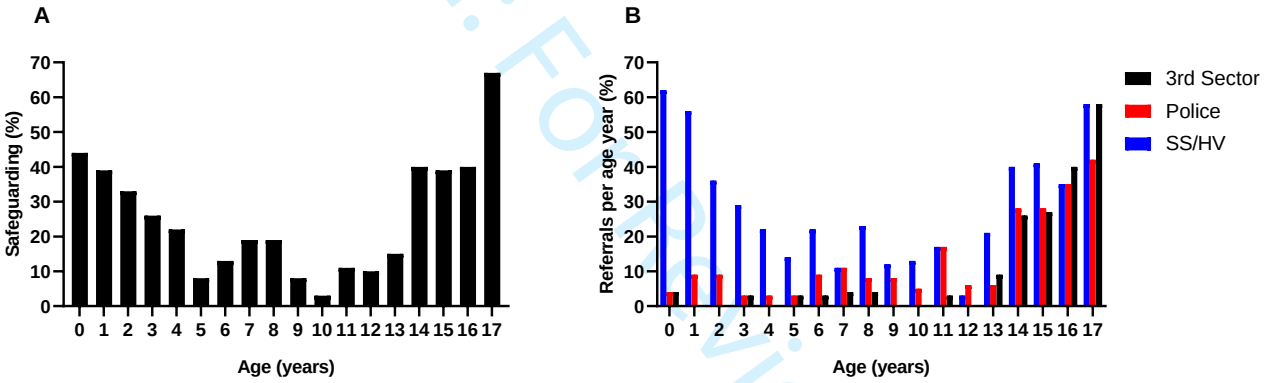
Figure 1



A. Bar graph shows the percentage of cases per age in years.

B. Stacked bar graph shows the proportion of children injured at home or in the street per age in years.

Figure 2



A. Bar graph shows the proportion of safeguarding referrals made per age in years.

B. Bar graph shows the referrals to social services/health visitor and involvement of police and 3rd sector organisations per age in years.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	6
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7/8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7/8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7/8
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7/8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	Table 1
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) Summarise follow-up time (eg, average and total amount)	Page 8/Table 1

Outcome data	15*	Report numbers of outcome events or summary measures over time	Page 8/9, Table 1 and 2, Figure 1and 2

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA – unadjusted numbers given 7/8/9
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 8 and 9, Tables 1 and 2, Figures 1 and 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	9/10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9/10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9/10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	No funding, statement page 2

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Paediatrics Open

The at risk child: a contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.

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Keywords:	Mortality, Epidemiology, Adolescent Health, Data Collection

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The at risk child: *a contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.*

Authors

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Required Statements

Transparency Declaration

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the evaluation being reported and that no important aspects of the study have been omitted.

Funding

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Competing interest statement

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: organisational support (provision of online secure platform for data sharing, SLACK) was provided by the Healthy London Partnership; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Authorship/Contributorship

Authors role and responsibilities have been detailed on submission of this manuscript. This multi-centre evaluation was contributed to by many individuals who have been named in the collaborators/ non-author contributors list.

Patient and Public Involvement

Patient or public involvement was not possible in the production of this work.

Data Sharing

The collaborators will consider sharing of data if an appropriate request is made.

Dissemination Declaration:

Dissemination of the results to participants is not applicable.

Ethical Approval and Consent:

This project met the criteria of a service evaluation therefore ethical approval and patient consent were not required.

Collaborators (Non-Author Contributors):

Paediatric Evaluation of the London Trauma System (PELoTS) Collaborators

- The London Trauma System
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  - Ross Davenport
  - Leila Razavi
  - Emily Beddows
  - Ben Anthony
  - Joseph Davies
- Healthy London Partnership
  - Giles Armstrong
  - Fran White
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  - Owen Morgan
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  - Robert Bentley
- St Mary's Hospital
  - Nic Alexander
  - Varsha Nemarugommula
  - Clare Rees
- The Royal London Hospital
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  - Anoushka Neal
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- Chelsea and Westminster Hospital
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- Princess Royal University Hospital
    - Gabrielle Budd
    - Angus Fitchie
    - Timothy Scott
    - Panamoottil Anil Kumar

Abstract:

• **Background:** Injury is a leading health burden in children yet relatively little is reported about the contemporary risks they face. Current national registry data may underrepresent the true burden of injury to children. We aim to analyse contemporary patterns of paediatric trauma and identify current factors putting children at risk of injury.

• **Methods:** A three month prospective multi-centre cohort evaluation of injured children across the London Major Trauma System. All children receiving a trauma team activation; meeting NICE CT head criteria; or admitted/transferred out due to trauma were included. Data were collected on demographics, mechanism and location of injury, and body region injured. The primary outcome was in-hospital mortality and secondary outcome was safeguarding concerns.

• **Results:** 659 children were included. Young children were more likely to be injured at home (0-5 year olds: 70.8%, n=167 vs. adolescents: 15.6%, n=31). Adolescents were more likely to be injured in the street (42.7%, n=85). Head trauma caused over half of injuries in 0-5 year olds (51.9%, n=121). Falls were common and increasingly prevalent in younger children, causing 56.6% (n=372) of injuries. In adolescents, penetrating violence caused more than one in five injuries (21.9%, n=50). Most injured children survived (99.8%, n=658). However, one in four (26.1%, n=172) had safeguarding concerns and a quarter of adolescents had police, third sector, or external agency involvement (23.2%, n=53).

• **Conclusions:** This study describes changing demographics of modern-day paediatric trauma and highlights the variance in injury patterns in young children and adolescents. Importantly it highlights differences in actual rates of injuries compared to those reported from current national registry data. We must understand real risks facing 21st century children to effectively safeguard future generations. The results provide an opportunity to reassess the current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

Introduction

Trauma remains the leading cause of death and morbidity for children and young people.(1) Historically, road related incidents were the greatest source of death and serious injury to children(1). Contemporary mechanisms of injury are evolving, with interpersonal violence(2,3) and falls(4,5) overtaking as the most common causes of injury in children. Effective safeguarding of children and young people requires an accurate understanding of contemporary risk, this is essential to underpin future injury prevention strategies, if the success of those reducing road related casualties is to be replicated(6). As mechanisms of injury in children evolve, the focus of injury prevention processes must also adapt. Accurate understanding of modern-day injury patterns is therefore essential to minimise risk and enhance child safety.

Falls, traditionally seen as a predominant cause of injury in the elderly, are now a leading mechanism in children.(4,5) Despite this, awareness of the burden of falls for children in the UK is limited(7), especially when compared to falls prevention strategies seen in older people. Falls frequently result in head injuries in children, the impact of which is subject to a growing body of evidence detailing the cognitive and socio-economic impacts of even mild traumatic brain injury in early years.(16)

Contemporary reports also reveal a rise in violence related injury in both young adult(2) and paediatric populations(8,9), however current violence reduction strategies focus mainly on young adults.(3,10) In 2018 a single centre study in London found a penetrating injury rate of 9.4% in under 16s(2). Yet in the same year, national trauma data suggested just 6% of injured children aged 16 or less suffered penetrating injuries in London.(11) These data may under-represent the true incidence of paediatric violence-related injury due to the volume of cases not currently meeting Trauma Audit Research Network (TARN) national registry inclusion criteria. Currently the contemporary risks, aetiology and demographics of paediatric injury is unknown. Accurate understanding of this is vital to ensure appropriately targeted, effective injury prevention strategies and safeguarding (11).

We aimed to characterise the incidence of trauma in children cared for within the London Major Trauma System (LMTS). The primary aim was to investigate the contemporary causes, risks and outcomes of injury for children in differing age cohorts. Secondly, we wished to evaluate safeguarding interventions associated with injured children.

Methods

A prospective paediatric trauma evaluation was carried out over a three-month period from February to April 2018. This time-frame was chosen for consistency with previous trauma service evaluations within our system.(12,13) The LMTS serves a wide geographical region(14). Four Major Trauma Centres (MTCs) care for severely injured children and young people, whilst 34 Trauma Units (TUs) manage the less severely injured and provide safe onwards transfer for those requiring MTC interventions (Supplementary item 1). All MTCs and TUs within the LMTS were invited to participate in the evaluation. Engagement was optimised through meetings with network leads and the pan-London Paediatric Trauma group. Each site registered the evaluation with local clinical audit teams and had a dedicated consultant clinical lead and data collectors. Anonymised data were collected by clinicians on children who met at least one of the following inclusion criteria:

- those who had a trauma team activation (Supplementary item 2);
- those who were admitted or transferred (to MTC or quaternary service) due to trauma;
- those who met NICE criteria for CT head due to trauma (to capture those not otherwise included in trauma team activation criteria).

In view of the frequency with which children with minor injuries present to emergency departments the inclusion criteria were defined to identify the most severely injured children. Those with isolated minor injuries not requiring admission to hospital, advanced imaging or activating the hospitals trauma team response were not included. Patients were also excluded if they were found to have had a non-trauma cause for presentation or if their age exceeded the hospital's definition of a child. Pre-hospital deaths were not included in this project. The definition of 'paediatric' varies across the system, therefore, to reflect real world practice a child was defined as birth-16 years or birth-18 years as per individual hospital determination. Adolescence was defined as >12 years age.

A case report form was completed for each patient. Data were collected on age, gender, mechanism of injury, location of injury, and injuries per body region. The primary outcome was in hospital mortality, secondary outcome was safeguarding concerns raised. Safeguarding children is defined by the UK government as *"preventing harm to children's health or development, taking action to enable all children and young people to have the best outcomes, to protect children from abuse and maltreatment and to ensure children grow up with the provision of safe and effective care."*(12) Safeguarding concerns could be raised by any clinical team member to highlight children or young people who may be at risk of harm. All children with safeguarding concerns were discussed in local psycho-social meetings as per local hospital policies and multidisciplinary team decisions were made regarding onward referral to social services and/or health visitor. Involvement of police and third sector organisations (including injury support and violence reduction programmes) were also captured. Children were followed up until they were discharged from hospital.

Descriptive statistics were used to compare differences between age cohorts (0-5 years, 6-11 years, and greater than 12 years). These cohorts reflect significant periods of child development: infancy, childhood, and adolescence. Continuous data are presented as medians with interquartile ranges. Categorical data are presented with percentages.

This project was conducted by clinical staff within each of the four trauma networks forming the LMTS and met the criteria of a service evaluation, therefore ethical approval was not required.

Results

During the three-month study period 665 children were identified within the 22 participating hospitals (all MTC's and 18 TU's). Six were excluded due to non-trauma causes or age exceeding the hospitals definition of a child, leaving 659 children included in the evaluation. Of these, half (52%) were cared for in an MTC and nearly two thirds were male (64.6%) (Table 1). Whilst the median age was 8.9 years [Interquartile range: 3.75-13.96] a bimodal distribution of age was identified, with peaks of injury in the very young (0-2 years) and in adolescence (Figure 1A). The youngest cohort (0-

5 years) was the largest (37%) followed by >12 years (35%) then those aged 6-11 years (28%) (Table 1).

Across the entire cohort, penetrating trauma accounted for 9.6% of injuries, however in adolescents, penetrating injury affected 1 in 5 (21.9%). The predominant blunt mechanism of injury was falls (56.5%). Road traffic collisions accounted for just 12.6% of injuries. Over a quarter of injured children required an operative intervention (29.4%) and admission to intensive care was 3.3%. Mortality was very low (<1%), with one child dying in the youngest cohort (Table 1). Similarly, hospital length of stay for survivors was short at a median of one day (IQR 1-3).

Location of injury differed according to age (Figure 1B). In younger children aged 0-5 years, the majority were injured in their home (70.8%). Almost three quarters of these younger children suffered falls (74.7%), with more than half of this age group sustaining head injuries (51.9%) (Table 1). Conversely, adolescent injuries commonly occurred in the street and almost a quarter of this age group (22.8%) were injured through interpersonal violence. Once again head injuries predominated however abdomino-thoracic trauma was greatest in adolescents compared to other age groups (10% vs. <1%, Table 1). Polytrauma affected a tenth of the cohort (11.4%) (Table 1).

Table 1: Demographics and injury characteristics of children and young people cared for in the London Major Trauma System February-April 2018

	All Children (n=659)	**0-5 years (n=247)**	**6-12 years (n=184)**	**12+ years (n=228)**	**p value**
Male	426 (64.6)	145 (59.4)	114 (62.0)	167 (73.2)	0.540
Female	233 (35.4)	102 (40.6)	70 (38.0)	61 (26.8)	0.008
Mechanism of injury:					
Blunt	596 (90.4)	243 (98.3)	175 (95.1)	178 (78.1)	**<0.001**
Penetrating	63 (9.6)	4 (1.7)	9 (4.9)	50 (21.9)	**<0.001**
Fall	372 (56.5)	184 (74.7)	109 (59.2)	79 (34.6)	**<0.001**
RTC	83 (12.6)	13 (5.3)	35 (19)	36 (15.8)	**<0.001**
Assault (all)	63 (9.5)	6 (2.4)	5 (2.7)	52 (22.8)	**<0.001**
Assault blunt	22 (3.3)	6 (2.4)	4 (2.2)	12 (5.3)	0.133
Assault penetrating	41 (6.2)	0 (0)	1 (0.5)	40 (17.5)	**<0.001**
Other*	139 (21.1)	43 (17.5)	35 (19)	61 (26.7)	**0.034**
Location of Injury					
Home	241 (40.5)	167 (70.8)	44 (27.5)	31 (15.6)	**<0.001**
School	98 (16.5)	16 (2.5)	45 (28.1)	37 (18.6)	**<0.001**
Street	152 (25.5)	21 (8.9)	46 (28.8)	85 (42.7)	**<0.001**
Other~	102 (17.1)	32 (13.6)	25 (15.6)	46 (23.1)	**0.026**
Body region injured:					
Head	252 (39.6)	121 (51.9)	65 (36.1)	66 (29.5)	**<0.001**
Upper limb	133 (20.9)	47 (20.2)	51 (28.3)	35 (15.6)	**0.007**
Lower Limb	113 (17.7)	26 (11.2)	35 (19.4)	52 (23.2)	**0.002**
Abdomino-thoracic	25 (3.9)	1 (0.4)	1 (0.5)	23 (10.3)	**<0.001**
Pelvis	4 (1.7)	0 (0)	2 (1.1)	2 (0.9)	0.302
Spine	19 (8)	1 (0.4)	8 (4.4)	10 (4.5)	**0.002**
Soft tissue	26 (11)	17 (7.3)	2 (1.1)	7 (3.1)	**0.005**
Face	23 (9.7)	13 (5.6)	8 (4.4)	2 (0.9)	**0.021**
Polytrauma**	27 (11.4)	2 (0.8)	5 (2.8)	20 (9.9)	**<0.001**

Management:					
MTC level care	343 (52)	126 (51.0)	91 (49.5)	126 (55.3)	0.462
Required Surgery	194 (29.4)	50 (20.2)	72 (39.1)	72 (31.5)	**<0.001**
Intensive Care Admission	22 (3.3)	5 (2.0)	7 (3.8)	10 (4.4)	0.329

All data are presented as n(%).
RTC: Road Traffic Collision, *Other includes sports injury, burns, deliberate self-harm. ~Other includes parks/recreation facilities/playgrounds, sports grounds, soft play locations. MTC: Major Trauma Centre. MTC level care: Any child or young person taken directly to or transferred to an MTC. Polytrauma: Two or more body regions injured.
Denominator changes where data was missing: Mechanism of injury: n=658 (blunt vs penetrating n=659), 0-5yrs n=246. Location of injury: all n=595, 0-5yrs n=236, 6-12yrs n=160, 12+yrs n=199. Body region injured: all n=637, 0-5yrs n=233, 6-12yrs n=180, 12+yrs n=224.

Safeguarding concerns were raised in 1 in 4 injured children (26.1%) (Table 2). These were identified in all age groups but bimodal peaks of concern were observed in the youngest (30.3%) and oldest children (33.3%) (Figure 2A). Overall, almost 1 in 3 children (30.6%) were referred to social services or the health visitor following their injury (Table 2) with similar bimodal peaks (Figure 2B). A fifth (49, 19.8%) of children in the 0-5 years cohort were under 1 year old, of these 45% (22) had safeguarding concerns and 63% (31) were referred for social services or health visitor input (Figures 2A and 2B). Almost a quarter of adolescents required input from the police and third sector organisations (Table 2) with a stepwise increase observed from age 13 years onwards.

Table 2: Outcomes

	All Children (n=659)	**0-5 years (n=247)**	**6-12 years (n=184)**	**12+ years (n=228)**	**p value**
Mortality	1 (0.15)	1 (0.4)	0 (0)	0 (0)	0.434
Safeguarding concern	172 (26.1)	75 (30.4)	21 (11.4)	76 (33.3)	**<0.001**
Referral to HV/SS	202 (30.6)	97 (39.3)	30 (16.3)	75 (32.9)	**<0.001**
Police Involvement	84 (12.7)	13 (5.3)	18 (9.8)	53 (23.2)	**<0.001**
3rd Sector/external agency involvement	61 (9.3)	4 (1.6)	4 (2.2)	53 (23.2)	**<0.001**
Hospital stay (days)~	1 (1-3)	1.5 (1-2)	1 (1-4.5)	2 (1-5)	**<0.001**

All data are presented as n(%) except for Hospital Stay (Median with Interquartile range)~. HV: Health Visitor; SS: Social Services.

Discussion

This project has characterised the contemporary incidence and mode of traumatic injury for children and young people within the LMTS through a prospective evaluation of those presenting to a trauma system not selected by Injury Severity Score (ISS) or length of stay. This includes data captured for all children and young people presenting with an injury or mechanism severe enough to require trauma team activation, admission or transfer for ongoing care, and/or CT head. This data offers a contemporary overview of paediatric trauma within a region and helps to fill existing knowledge gaps present due to the current national registry inclusion criteria. Data were captured from children managed in both MTC and TU settings, including both rural and inner-city populations using the same core methodology as previous trauma service evaluations.(13,14)

Variation exists in the pattern of injuries seen in childhood and adolescence. Differences were seen in the location of injuries, with preschool age children most likely to be injured in their homes compared to older children and adolescents, who were most likely to be injured in the street. Traditional mechanisms of trauma associated with children, such as road traffic collisions, were less evident, with falls the primary cause of injury in the younger cohort whilst a demonstrable rise in interpersonal violence and penetrating injuries was observed in adolescence. Head injuries predominated across all age groups with over half of the younger children affected. The higher rate of abdomino-thoracic injuries seen in adolescents is thought to be associated with increased penetrating trauma in this group (Supplementary table 1). A quarter of the children included in this evaluation had significant safeguarding concerns raised and one in four adolescents required input from police and/or third sector organisations. Mortality was low (0.2%) contrasting with previous reports of 8.8% in severely injured(14) and 3.1% in moderately inured children and we are unable to account for this.(5) Deaths may have occurred at scene, not captured by this project. Our cohort contained children of all injury severities and was not limited by TARN inclusion criteria, therefore factors such as the maturation of the trauma system may have contributed to increased survival.(13)

This study highlights differences in how children and adolescents sustain traumatic injury. In our cohort, the predominant cause of injury in children was falling. This was greater in younger children, a group most at risk of injury in their home environment. Injury in the home is common and offers opportunity for injury prevention.(15) Children aged 0-5 years were most likely to suffer head injuries. Previous reports have suggested toddlers, aged 1-4 years, have the lowest rates of head injury, however such reports have limited their data to moderate to severe injury.(5) By expanding our cohort, we highlight the risk of head injuries in this age group, most sustained as the result of accidental falls. The consequences of falls in this age group, particularly those with mild traumatic brain injury, are increasingly appreciated, with evidence suggesting lasting cognitive effects for the individual and economic effects for society.(16) Understanding the true burden and the avoidable nature of these injuries makes head injury prevention a paediatric public health priority.

Interpersonal violence poses a serious risk to adolescents(2)(8) with one fifth sustaining injuries due to alleged assault, the vast majority of which were penetrating. This equates to one child every two days suffering penetrating injuries across our region. Reported rates of paediatric penetrating injuries have previously been much lower, 2.2%.(5) Our findings highlight how current national registry eligibility criteria may underestimate the reality of paediatric penetrating injury nationally as many will stay in hospital for less than three days or not require critical care admission. Accurate understanding of the true volume of these injuries is vital if we are to effectively target resources for injury prevention. Prevention strategies must recognise the involvement of younger children and capitalise on the potential for intervention in this group to break the cycle of children later presenting as young adults with life threatening injuries.

Safeguarding remains a major concern in contemporary paediatric trauma care. The need for safeguarding was raised in a quarter of cases and this was highest in both the youngest group and adolescents. It is known infants under one year are at the highest risk of non-accidental injury (NAI).(17) Educational programmes introduced to aid parents to develop coping strategies for crying babies have been highlighted as important in reducing the risk of these youngest and most vulnerable children.(18-20) The bimodal distribution of safeguarding concerns also highlights the need to consider the unique safeguarding challenges faced by adolescents(21). Our findings question

what effective modern day safeguarding in children and adolescents looks like. Safeguarding children has traditionally been viewed as a family experience, with support for caregivers being of paramount importance in preventing harm to children. The same view is not currently taken for children or adolescents as the victims of interpersonal violence. Historically effort has focused on the prevention and identification of NAI, often at the hands of caregivers.(22) Yet safeguarding practices must also reflect the contemporary risks of intentional interpersonal violence and the prevention of avoidable harm from unintentional injury which may impact a child's ability to reach their full potential. Early years interventions may be vital in reducing these risks(23).

Limitations exist in this project. Firstly, some of the smaller TUs were unable to participate due to service commitments therefore cases will have been missed. However, each of the four major trauma centres participated, suggesting that the most severely injured children were included. Although the LMTS serves both urban and rural populations, we acknowledge these findings may not be representative of all trauma networks. The project ran for a period of three months, the time frame chosen in line with previous trauma service evaluations, therefore seasonal differences in attendance may not be accounted for. ISS were not collected for all included children therefore overall analysis of injury severity was not possible. Some physician or institutional variations may exist between hospitals however LMTS has paediatric trauma guidelines which promote standardisation across the units. Finally, children whose injuries or mechanism were not severe enough to meet the inclusion criteria were not included, incorporation of these may have identified other patterns of injury which may yield further opportunities for injury prevention.

By expanding our lens, this evaluation has bridged a gap in understanding paediatric trauma, however many learning opportunities remain. Further research would ideally include a yearlong, national study, removing seasonal and geographical variation, to include data capture on pre-hospital deaths, emergency department discharges and longer-term outcomes.

Finally, injured children should not be thought of in isolation. Consideration must be given to the families and wider support networks which play a vital role in prevention and in rehabilitation. As such, opportunities for patient and family engagement in future work and co-development of injury prevention strategies must be at the forefront.

Conclusion

This evaluation has described the changing demographics of contemporary paediatric trauma and has highlighted the variance in injury patterns in young children and adolescents. Importantly it has highlighted differences in actual rates of injuries compared to those levels reported from current national registry data. The importance of a contemporary understanding of the real risks facing children in the 21st century cannot be underestimated if we are to safeguard our future generations effectively. The results provide an opportunity to reassess our current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

What is known about this subject?

- Trauma is the leading cause of death in children
- Injury patterns vary across age groups
- Falls are the most common cause of injuries in under 5's

What does this work add?

- National registry criteria vastly underrepresents the true volume of paediatric trauma
- Prevalence of interpersonal violence in children and adolescents is significantly higher than previously reported
- Traditional approaches to safeguarding must be modernised to reflect contemporary risks of interpersonal violence and avoidable harm

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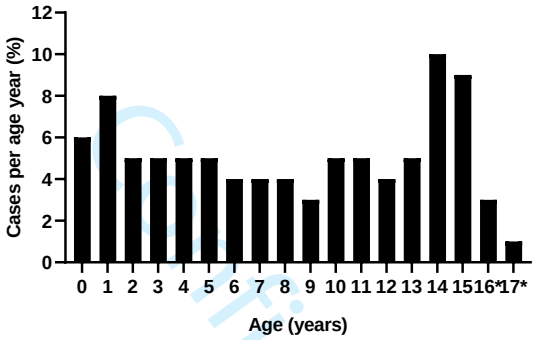
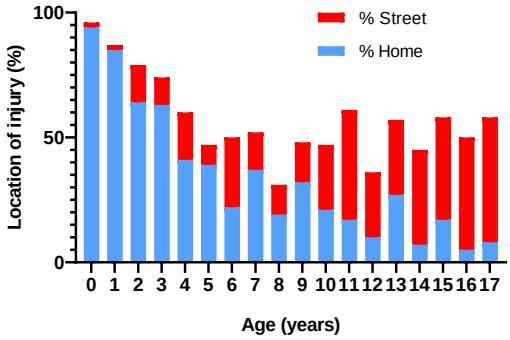
Figure 1

A



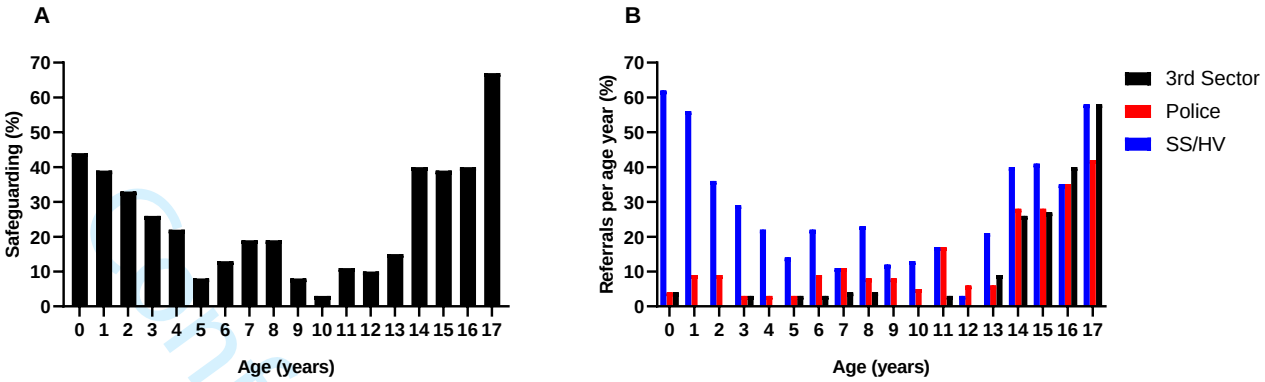
B



A. Bar graph shows the percentage of cases per age in years. (*16/17 year-olds classified as paediatric in 2/22 hospitals)

B. Stacked bar graph shows the proportion of children injured at home or in the street per age in years.

Figure 2



A. Bar graph shows the proportion of safeguarding referrals made per age in years.

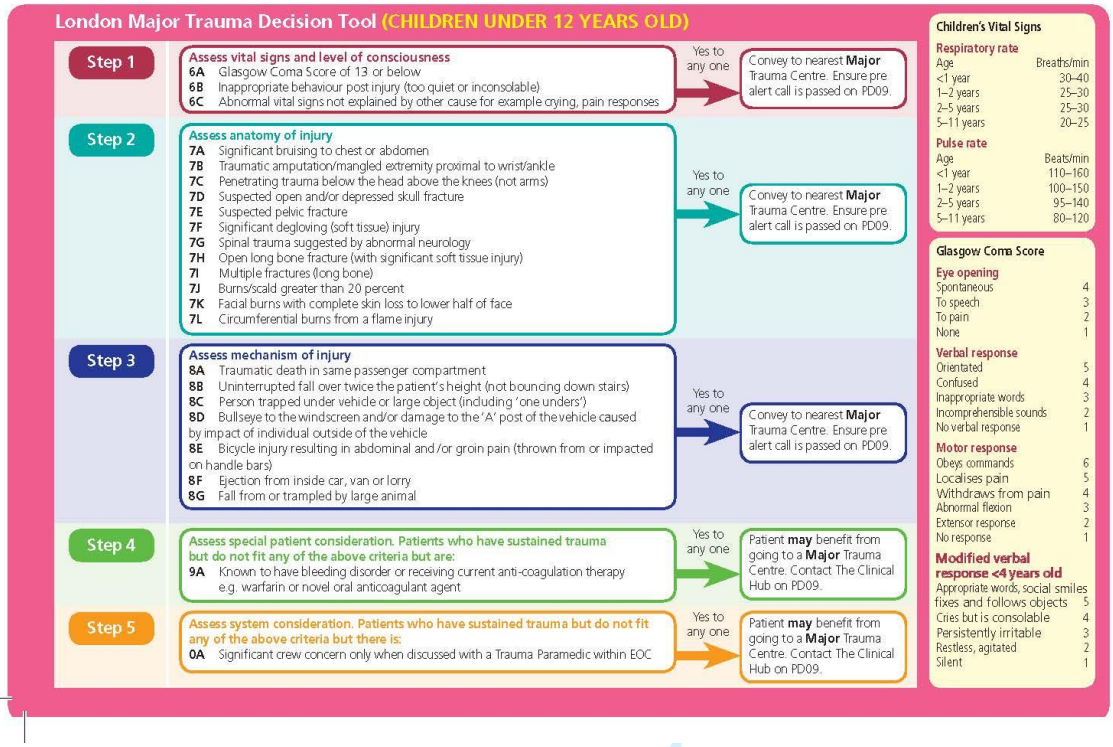
B. Bar graph shows the referrals to social services/health visitor and involvement of police and 3rd sector organisations per age in years.

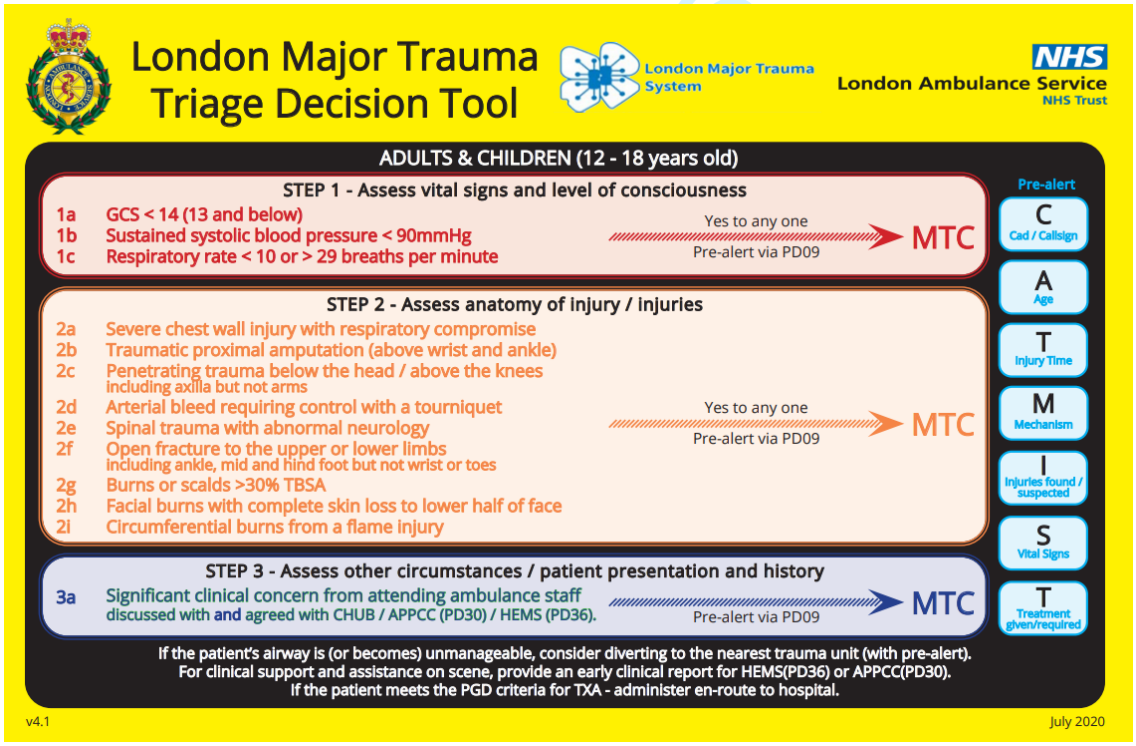
Supplemental Table 1: Body Region Injured

	Blunt Mechanism (n=596*)	Penetrating Mechanism (n=63~)
Head	252 (42.3)	0 (0)
Upper limb	126 (21.1)	7 (11.1)
Lower Limb	93 (15.6)	20 (31.7)
Thoraco-abdominal	10 (1.7)	15 (23.8)
Pelvis	4 (0.7)	0 (0)
Spine	19 (3.2)	0 (0)
Soft tissue	20 (3.4)	6 (9.5)
Face	20 (3.4)	3 (4.8)
Polytrauma	16 (2.7)	11 (17.5)

*15 cases with significant mechanism of injury but no injury identified, 21 cases body region injured not documented. ~1 case body region not recorded.

Supplementary item 1: Example of a pre-hospital care trauma triage tool to determine where children and young adults with trauma will be transported for care. (Available at https://www.c4ts.qmul.ac.uk/london-trauma-system/clinical-policies-and-documents (Accessed June 2021)





Supplementary Item 2: Example of a local trauma team activation policy (Reference: UCLH Trauma Operational Policy, January 2019)

NORTH EAST LONDON & ESSEX TRAUMA NETWORK

University College London Hospitals NHS
NHS Foundation Trust

UCH TRAUMA UNIT

Paediatric trauma call criteria

A trauma call may be initiated at any time in the emergency department by any doctor or nurse.
Call 2222 and state "PAEDIATRIC TRAUMA TEAM TO EMERGENCY DEPARTMENT RESUS ROOM."
Then make the following PA announcement (for every trauma call):
"TRAUMA TEAM LEADER & NURSE IN CHARGE TO RESUS FOR PAEDIATRIC TRAUMA CALL."

INJURED CHILDREN

BEWARE

USE AGE-APPROPRIATE VITAL SIGNS AND MODIFIED GCS / AVPU SCORES.

SEEK SENIOR HELP EARLY. IF IN DOUBT TRAUMA CALL

REMEMBER SAFEGUARDING

Mechanism

Fall more than twice the child's height

RTC passenger **>30mph**

RTC ejection from vehicle

RTC death of other passenger in RTC

RTC rollover or significant vehicle deformation

RTC pedestrian or **cyclist** vs. vehicle

Bicycle injury resulting in groin / abdominal pain

Fall from or trampled by large animal

Entrapment >30mins

Gunshot wound

Major crush injury

Blast injury

HEMS call

Physiology

History of trauma and any one of:

Intubated patient

Respiratory rate outside the range given in the table to the right

Hypoxia

Heart rate outside the range given in the table to the right

Reduced **conscious level** (GCS <14 or less than A on AVPU) and/or significant **confusion** or **agitation**

Limb paralysis, paraplegia or quadriplegia

Injury pattern

Potential **airway injury**

Significant **chest injury**

Major haemorrhage

Burns >20% BSA
(**Burns** >15% BSA in children younger than 1 year)

Facial burns or **circumferential burns**

Penetrating injury to **head, neck, or torso**

Penetrating injury to arm **proximal to elbow**

Penetrating injury to leg **proximal to knee**

Amputation or **open fracture** proximal to wrist

Amputation or **open fracture** proximal to ankle

Suspected **pelvic fracture**

2 or more suspected **long bone fractures**

CHILDREN'S NORMAL VITAL SIGNS

Age (years)	Resp. rate (min^{-1})	Pulse rate (min^{-1})
< 1	30 – 40	110 – 160
1 – 2	25 – 30	100 – 150
2 – 5	25 – 30	95 – 140
5 – 11	20 – 25	80 – 120
> 12	12 – 20	60 – 100

Please document in the **trauma booklet** for all trauma call patients and change the EPR presenting complaint to **TRAUMA CALL**. Leave a copy of the completed trauma booklet in the box in resuscitation bay 1.

uclh

BMJ Paediatrics Open

The at risk child: a contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.

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Keywords:	Mortality, Epidemiology, Adolescent Health, Data Collection

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The at risk child: *a contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.*

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Required Statements

Transparency Declaration

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the evaluation being reported and that no important aspects of the study have been omitted.

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No funding was received to undertake this evaluation.

Copyright

Competing interest statement

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: organisational support (provision of online secure platform for data sharing, SLACK) was provided by the Healthy London Partnership; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Authorship/Contributorship

Authors role and responsibilities have been detailed on submission of this manuscript. This multi-centre evaluation was contributed to by many individuals who have been named in the collaborators/ non-author contributors list.

Patient and Public Involvement

Patient or public involvement was not possible in the production of this work.

Data Sharing

The collaborators will consider sharing of data if an appropriate request is made.

Dissemination Declaration:

Dissemination of the results to participants is not applicable.

Ethical Approval and Consent:

This project met the criteria of a service evaluation therefore ethical approval and patient consent were not required.

Collaborators (Non-Author Contributors):

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Abstract:

• **Background:** Injury is a leading health burden in children yet relatively little is reported about the contemporary risks they face. Current national registry data may underrepresent the true burden of injury to children. We aim to analyse contemporary patterns of paediatric trauma and identify current factors putting children at risk of injury.

• **Methods:** A three month prospective multi-centre cohort evaluation of injured children across the London Major Trauma System. All children receiving a trauma team activation; meeting NICE CT head criteria; or admitted/transferred out due to trauma were included. Data were collected on demographics, mechanism and location of injury, and body region injured. The primary outcome was in-hospital mortality and secondary outcome was safeguarding concerns.

• **Results:** 659 children were included. Young children were more likely to be injured at home (0-5 year olds: 70.8%, n=167 vs. adolescents: 15.6%, n=31). Adolescents were more likely to be injured in the street (42.7%, n=85). Head trauma caused over half of injuries in 0-5 year olds (51.9%, n=121). Falls were common and increasingly prevalent in younger children, causing 56.6% (n=372) of injuries. In adolescents, penetrating violence caused more than one in five injuries (21.9%, n=50). Most injured children survived (99.8%, n=658). However, one in four (26.1%, n=172) had safeguarding concerns and a quarter of adolescents had police, third sector, or external agency involvement (23.2%, n=53).

• **Conclusions:** This study describes modern-day paediatric trauma and highlights the variance in injury patterns in young children and adolescents. Importantly it highlights differences in actual rates of injuries compared to those reported from current national registry data. We must understand real risks facing 21st century children to effectively safeguard future generations. The results provide an opportunity to reassess the current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

Introduction

Trauma remains the leading cause of death and morbidity for children and young people.(1) Historically, road related incidents were the greatest source of death and serious injury to children(1). Contemporary mechanisms of injury are evolving, with interpersonal violence(2,3) and falls(4,5) overtaking as the most common causes of injury in children. Effective safeguarding of children and young people requires an accurate understanding of contemporary risk, this is essential to underpin future injury prevention strategies, if the success of those reducing road related casualties is to be replicated(6). As mechanisms of injury in children evolve, the focus of injury prevention processes must also adapt. Accurate understanding of modern-day injury patterns is therefore essential to minimise risk and enhance child safety.

Falls, traditionally seen as a predominant cause of injury in the elderly, are now a leading mechanism in children.(4,5) Despite this, awareness of the burden of falls for children in the UK is limited(7), especially when compared to falls prevention strategies seen in older people. Falls frequently result in head injuries in children, the impact of which is subject to a growing body of evidence detailing the cognitive and socio-economic impacts of even mild traumatic brain injury in early years.(16)

Contemporary reports also reveal a rise in violence related injury in both young adult(2) and paediatric populations(8,9), however current violence reduction strategies focus mainly on young adults.(3,10) In 2018 a single centre study in London found a penetrating injury rate of 9.4% in under 16s(2). Yet in the same year, national trauma data suggested just 6% of injured children aged 16 or less suffered penetrating injuries in London.(11) These data may under-represent the true incidence of paediatric violence-related injury due to the volume of cases not currently meeting Trauma Audit Research Network (TARN) national registry inclusion criteria. Currently the contemporary risks, aetiology and demographics of paediatric injury is unknown. Accurate understanding of this is vital to ensure appropriately targeted, effective injury prevention strategies and safeguarding (11).

We aimed to characterise the incidence of trauma in children cared for within the London Major Trauma System (LMTS). The primary aim was to investigate the contemporary causes, risks and outcomes of injury for children in differing age cohorts. Secondly, we wished to evaluate safeguarding interventions associated with injured children.

Methods

A prospective paediatric trauma evaluation was carried out over a three-month period from February to April 2018. This time-frame was chosen for consistency with previous trauma service evaluations within our system.(12,13) The LMTS serves a wide geographical region(14). Four Major Trauma Centres (MTCs) care for severely injured children and young people, whilst 34 Trauma Units (TUs) manage the less severely injured and provide safe onwards transfer for those requiring MTC interventions (Supplementary item 1). All MTCs and TUs within the LMTS were invited to participate in the evaluation. Engagement was optimised through meetings with network leads and the pan-London Paediatric Trauma group. Each site registered the evaluation with local clinical audit teams and had a dedicated consultant clinical lead and data collectors. Anonymised data were collected by clinicians on children who met at least one of the following inclusion criteria:

- those who had a trauma team activation (Supplementary item 2);
- those who were admitted or transferred (to MTC or quaternary service) due to trauma;
- those who met NICE criteria for CT head due to trauma (to capture those not otherwise included in trauma team activation criteria).

In view of the frequency with which children with minor injuries present to emergency departments the inclusion criteria were defined to identify the most severely injured children. Those with isolated minor injuries not requiring admission to hospital, advanced imaging or activating the hospitals trauma team response were not included. Patients were also excluded if they were found to have had a non-trauma cause for presentation or if their age exceeded the hospital's definition of a child. Pre-hospital deaths were not included in this project. The definition of 'paediatric' varies across the system, therefore, to reflect real world practice a child was defined as birth-16 years or birth-18 years as per individual hospital determination. Due to a lack of consensus in the literature, the study group decided to define adolescence as ≥12 years of age.

A case report form was completed for each patient. Data were collected on age, gender, mechanism of injury, location of injury, and injuries per body region. The primary outcome was in hospital mortality, secondary outcome was safeguarding concerns raised. Safeguarding children is defined by the UK government as *"preventing harm to children's health or development, taking action to enable all children and young people to have the best outcomes, to protect children from abuse and maltreatment and to ensure children grow up with the provision of safe and effective care."*(12) Safeguarding concerns could be raised by any clinical team member to highlight children or young people who may be at risk of harm. All children with safeguarding concerns were discussed in local psycho-social meetings as per local hospital policies and multidisciplinary team decisions were made regarding onward referral to social services and/or health visitor. Involvement of police and third sector organisations (including injury support and violence reduction programmes) were also captured. Children were followed up until they were discharged from hospital.

Descriptive statistics were used to compare differences between age cohorts (0-5 years, 6-11 years, and ≥12 years). These cohorts reflect significant periods of child development: infancy, childhood, and adolescence. Continuous data are presented as medians with interquartile ranges. Categorical data are presented with percentages.

This project was conducted by clinical staff within each of the four trauma networks forming the LMTS and met the criteria of a service evaluation, therefore ethical approval was not required.

Results

During the three-month study period 665 children were identified within the 22 participating hospitals (all MTC's and 18 TU's). Six were excluded due to non-trauma causes or age exceeding the hospitals definition of a child, leaving 659 children included in the evaluation. Of these, 52% were cared for in an MTC and nearly two thirds were male (64.6%) (Table 1). The median age was 8.9 years [Interquartile range: 3.75-13.96]. A bimodal distribution of age was identified, with peaks of

injury in the very young (0-2 years) and in adolescence (Figure 1A). The youngest cohort (0-5 years) was the largest (37%) followed by ≥12 years (35%) then those aged 6-11 years (28%) (Table 1).

Across the entire cohort, penetrating trauma accounted for 9.6% of injuries, however in adolescents, penetrating injury affected 1 in 5 (21.9%). The predominant blunt mechanism of injury was falls (56.5%). Road traffic collisions accounted for 12.6% of injuries. Over a quarter of injured children required an operative intervention (29.4%) and admission to intensive care was 3.3%. Mortality was <1%, with one child dying in the youngest cohort (Table 1). The median hospital length of stay for survivors was one day (IQR 1-3).

Location of injury differed according to age (Figure 1B). In younger children aged 0-5 years, the majority were injured in their home (70.8%). Almost three quarters of these younger children suffered falls (74.7%), with more than half of this age group sustaining head injuries (51.9%) (Table 1). Conversely, adolescent injuries commonly occurred in the street and almost a quarter of this age group (22.8%) were injured through interpersonal violence. Once again head injuries predominated however abdomino-thoracic trauma was greatest in adolescents compared to other age groups (10% vs. <1%, Table 1). Polytrauma affected approximately a tenth of the cohort (11.4%) (Table 1).

Table 1: Demographics and injury characteristics of children and young people cared for in the London Major Trauma System February-April 2018

	All Children (n=659)	0-5 years (n=247)	6-12 years (n=184)	≥12 years (n=228)	p value
Male	426 (64.6)	145 (59.4)	114 (62.0)	167 (73.2)	0.540
Female	233 (35.4)	102 (40.6)	70 (38.0)	61 (26.8)	0.008
Mechanism of injury:					
Blunt	596 (90.4)	243 (98.3)	175 (95.1)	178 (78.1)	**<0.001**
Penetrating	63 (9.6)	4 (1.7)	9 (4.9)	50 (21.9)	**<0.001**
Fall	372 (56.5)	184 (74.7)	109 (59.2)	79 (34.6)	**<0.001**
RTC	83 (12.6)	13 (5.3)	35 (19)	36 (15.8)	**<0.001**
Assault (all)	63 (9.5)	6 (2.4)	5 (2.7)	52 (22.8)	**<0.001**
Assault blunt	22 (3.3)	6 (2.4)	4 (2.2)	12 (5.3)	0.133
Assault penetrating	41 (6.2)	0 (0)	1 (0.5)	40 (17.5)	**<0.001**
Other*	139 (21.1)	43 (17.5)	35 (19)	61 (26.7)	**0.034**
Location of Injury					
Home	241 (40.5)	167 (70.8)	44 (27.5)	31 (15.6)	**<0.001**
School	98 (16.5)	16 (2.5)	45 (28.1)	37 (18.6)	**<0.001**
Street	152 (25.5)	21 (8.9)	46 (28.8)	85 (42.7)	**<0.001**
Other~	102 (17.1)	32 (13.6)	25 (15.6)	46 (23.1)	**0.026**
Body region injured:					
Head	252 (39.6)	121 (51.9)	65 (36.1)	66 (29.5)	**<0.001**
Upper limb	133 (20.9)	47 (20.2)	51 (28.3)	35 (15.6)	**0.007**
Lower Limb	113 (17.7)	26 (11.2)	35 (19.4)	52 (23.2)	**0.002**
Abdomino-thoracic	25 (3.9)	1 (0.4)	1 (0.5)	23 (10.3)	**<0.001**
Pelvis	4 (1.7)	0 (0)	2 (1.1)	2 (0.9)	0.302
Spine	19 (8)	1 (0.4)	8 (4.4)	10 (4.5)	**0.002**
Soft tissue	26 (11)	17 (7.3)	2 (1.1)	7 (3.1)	**0.005**
Face	23 (9.7)	13 (5.6)	8 (4.4)	2 (0.9)	**0.021**
Polytrauma**	27 (11.4)	2 (0.8)	5 (2.8)	20 (9.9)	**<0.001**

Management:					
MTC level care	343 (52)	126 (51.0)	91 (49.5)	126 (55.3)	0.462
Required Surgery	194 (29.4)	50 (20.2)	72 (39.1)	72 (31.5)	**<0.001**
Intensive Care Admission	22 (3.3)	5 (2.0)	7 (3.8)	10 (4.4)	0.329

All data are presented as n(%).
RTC: Road Traffic Collision, *Other includes sports injury, burns, deliberate self-harm. ~Other includes parks/recreation facilities/playgrounds, sports grounds, soft play locations. MTC: Major Trauma Centre. MTC level care: Any child or young person taken directly to or transferred to an MTC. Polytrauma: Two or more body regions injured.
Denominator changes where data was missing: Mechanism of injury: n=658 (blunt vs penetrating n=659), 0-5yrs n=246. Location of injury: all n=595, 0-5yrs n=236, 6-12yrs n=160, 12+yrs n=199. Body region injured: all n=637, 0-5yrs n=233, 6-12yrs n=180, 12+yrs n=224.

Safeguarding concerns were raised in 1 in 4 injured children (26.1%) (Table 2). These were identified in all age groups but bimodal peaks of concern were observed in the youngest (30.3%) and oldest children (33.3%) (Figure 2A). Overall, almost 1 in 3 children (30.6%) were referred to social services or the health visitor following their injury (Table 2) with similar bimodal peaks (Figure 2B). 49 (19.8%) children in the 0-5 years cohort were under 1 year old, of these 45% (22) had safeguarding concerns and 63% (31) were referred for social services or health visitor input (Figures 2A and 2B). Almost a quarter of adolescents required input from the police and third sector organisations (Table 2) with a stepwise increase observed from age 13 years onwards.

Table 2: Outcomes

	All Children (n=659)	**0-5 years (n=247)**	**6-12 years (n=184)**	**≥12 years (n=228)**	**p value**
Mortality	1 (0.15)	1 (0.4)	0 (0)	0 (0)	0.434
Safeguarding concern	172 (26.1)	75 (30.4)	21 (11.4)	76 (33.3)	**<0.001**
Referral to HV/SS	202 (30.6)	97 (39.3)	30 (16.3)	75 (32.9)	**<0.001**
Police Involvement	84 (12.7)	13 (5.3)	18 (9.8)	53 (23.2)	**<0.001**
3rd Sector/external agency involvement	61 (9.3)	4 (1.6)	4 (2.2)	53 (23.2)	**<0.001**
Hospital stay (days)~	1 (1-3)	1.5 (1-2)	1 (1-4.5)	2 (1-5)	**<0.001**

All data are presented as n(%) except for Hospital Stay (Median with Interquartile range)~. HV: Health Visitor; SS: Social Services.

Discussion

This project has characterised the contemporary incidence and mode of traumatic injury for children and young people within the LMTS through a prospective evaluation of those presenting to a trauma system not selected by Injury Severity Score (ISS) or length of stay. This includes data captured for all children and young people presenting with an injury or mechanism severe enough to require trauma team activation, admission or transfer for ongoing care, and/or CT head. This data offers a contemporary overview of paediatric trauma within a region and helps to fill existing knowledge gaps present due to the current national registry inclusion criteria. Data were captured from children and young people managed in both MTC and TU settings, including both rural and inner-city populations using the same core methodology as previous trauma service evaluations.(13,14)

Variation exists in the pattern of injuries seen in childhood and adolescence. Differences were seen in the location of injuries, with preschool age children most likely to be injured in their homes compared to older children and adolescents, who were most likely to be injured in the street. Traditional mechanisms of trauma associated with children and young people, such as road traffic collisions, were less evident, with falls the primary cause of injury in the younger cohort whilst a demonstrable rise in interpersonal violence and penetrating injuries was observed in adolescence. Head injuries predominated across all age groups with over half of the younger children affected. The higher rate of abdomino-thoracic injuries seen in adolescents is thought to be associated with increased penetrating trauma in this group (Supplementary table 1). A quarter of the children and young people included in this evaluation had significant safeguarding concerns raised and one in four adolescents required input from police and/or third sector organisations. Mortality was low (0.2%) contrasting with previous reports of 8.8% in severely injured(14) and 3.1% in moderately injured children and we are unable to account for this.(5) Deaths may have occurred at scene, not captured by this project. Our cohort contained children and young people of all injury severities and was not limited by TARN inclusion criteria, other factors such as the maturation of the trauma system may have contributed to increased survival.(13)

This study highlights differences in how children and adolescents sustain traumatic injury. In our cohort, the predominant cause of injury in children and young people was falling. This was greater in younger children, a group most at risk of injury in their home environment. Injury in the home is common and offers opportunity for injury prevention.(15) Children aged 0-5 years were most likely to suffer head injuries. Previous reports have suggested toddlers, aged 1-4 years, have the lowest rates of head injury, however such reports have limited their data to moderate to severe injury.(5) By expanding our cohort, we highlight the risk of head injuries in this age group, most sustained as the result of accidental falls. The consequences of falls in this age group, particularly those with mild traumatic brain injury, are increasingly appreciated, with evidence suggesting lasting cognitive effects for the individual and economic effects for society.(16) Understanding the true burden and the avoidable nature of these injuries makes head injury prevention a paediatric public health priority.

Interpersonal violence poses a serious risk to adolescents(2)(8) with one fifth sustaining injuries due to alleged assault, the vast majority of which were penetrating. This equates to one child every two days suffering penetrating injuries across our region. Reported rates of paediatric penetrating injuries have previously been much lower, 2.2%.(5) Our findings highlight how current TARN eligibility criteria may underestimate the reality of paediatric penetrating injury as many will stay in hospital for less than three days or not require critical care admission. Accurate understanding of the true volume of these injuries is vital if we are to effectively target resources for injury prevention. Prevention strategies must recognise the involvement of younger children and capitalise on the potential for intervention in this group to break the cycle of children later presenting as young adults with life threatening injuries.

Safeguarding remains a major concern in contemporary paediatric trauma care. The need for safeguarding was raised in a quarter of cases and this was highest in both the youngest group and adolescents. It is known infants under one year are at the highest risk of non-accidental injury (NAI).(17) Educational programmes introduced to aid parents to develop coping strategies for crying babies have been highlighted as important in reducing the risk of these youngest and most

vulnerable children.(18-20) The bimodal distribution of safeguarding concerns also highlights the need to consider the unique safeguarding challenges faced by adolescents(21). Our findings question what effective modern day safeguarding in children and adolescents looks like. Safeguarding children and young people has traditionally been viewed as a family experience, with support for caregivers being of paramount importance in preventing harm to children. The same view is not currently taken for children or adolescents as the victims of interpersonal violence. Historically effort has focused on the prevention and identification of NAI, often at the hands of caregivers.(22) Yet safeguarding practices must also reflect the contemporary risks of intentional interpersonal violence and the prevention of avoidable harm from unintentional injury which may impact a child's ability to reach their full potential. Early years interventions may be vital in reducing these risks(23).

Limitations exist in this project. Firstly, some of the smaller TUs were unable to participate due to service commitments therefore cases will have been missed. However, each of the four major trauma centres participated, suggesting that the most severely injured children were included. Our definition of adolescents and the varying upper age limit may not reflect paediatric practice elsewhere, however this illustrates the real world variation seen across different settings. Although the LMTS serves both urban and rural populations, we acknowledge these findings may not be representative of all trauma networks. The high proportion of penetrating injuries seen in our cohort may not currently represent the entire UK however with the rising incidence of violence and county lines safeguarding issues, it is essential to raise awareness of this and the need for prevention. The project ran for a period of three months, the time frame chosen in line with previous trauma service evaluations, therefore seasonal differences in attendance may not be accounted for. ISS were not collected for all included children therefore overall analysis of injury severity was not possible. This may also affect mortality comparisons, however only one child died during our study period. Some physician or institutional variations may exist between hospitals however LMTS has paediatric trauma guidelines which promote standardisation across the units. Finally, children whose injuries or mechanism were not severe enough to meet the inclusion criteria were not included, incorporation of these may have identified other patterns of injury which may yield further opportunities for injury prevention.

By expanding our lens, this evaluation has bridged a gap in understanding paediatric trauma, however many learning opportunities remain. Further research would ideally include a yearlong, national study, removing seasonal and geographical variation, to include data capture on pre-hospital deaths, emergency department discharges and longer-term outcomes.

Finally, injured children should not be thought of in isolation. Consideration must be given to the families and wider support networks which play a vital role in prevention and in rehabilitation. As such, opportunities for patient and family engagement in future work and co-development of injury prevention strategies must be at the forefront.

Conclusion

This evaluation has described the changing demographics of contemporary paediatric trauma and has highlighted the variance in injury patterns in young children and adolescents. Importantly it has highlighted differences in actual rates of injuries compared to those levels reported from current national registry data. The importance of a contemporary understanding of the real risks facing

children in the 21st century cannot be underestimated if we are to safeguard our future generations effectively. The results provide an opportunity to reassess our current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

What is known about this subject?

- Trauma is the leading cause of death in children
- Injury patterns vary across age groups
- Falls are the most common cause of injuries in under 5's

What does this work add?

- National registry criteria vastly underrepresents the true volume of paediatric trauma
- Prevalence of interpersonal violence in children and adolescents is significantly higher than previously reported
- Traditional approaches to safeguarding must be modernised to reflect contemporary risks of interpersonal violence and avoidable harm

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The at risk child: *a contemporary analysis of injured children in London and the South East of England. A prospective, multicentre cohort study.*

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Required Statements

Transparency Declaration

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the evaluation being reported and that no important aspects of the study have been omitted.

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Copyright

Competing interest statement

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: organisational support (provision of online secure platform for data sharing, SLACK) was provided by the Healthy London Partnership; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Authorship/Contributorship

Authors role and responsibilities have been detailed on submission of this manuscript. This multi-centre evaluation was contributed to by many individuals who have been named in the collaborators/ non-author contributors list.

Patient and Public Involvement

Patient or public involvement was not possible in the production of this work.

Data Sharing

The collaborators will consider sharing of data if an appropriate request is made.

Dissemination Declaration:

Dissemination of the results to participants is not applicable.

Ethical Approval and Consent:

This project met the criteria of a service evaluation therefore ethical approval and patient consent were not required.

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Abstract:

• **Background:** Injury is a leading health burden in children yet relatively little is reported about the contemporary risks they face. Current national registry data may underrepresent the true burden of injury to children. We aim to analyse contemporary patterns of paediatric trauma and identify current factors putting children at risk of injury.

• **Methods:** A three month prospective multi-centre cohort evaluation of injured children across the London Major Trauma System. All children receiving a trauma team activation; meeting NICE CT head criteria; or admitted/transferred out due to trauma were included. Data were collected on demographics, mechanism and location of injury, and body region injured. The primary outcome was in-hospital mortality and secondary outcome was safeguarding concerns.

• **Results:** 659 children were included. Young children were more likely to be injured at home (0-5 year olds: 70.8%, n=167 vs. adolescents: 15.6%, n=31). Adolescents were more likely to be injured in the street (42.7%, n=85). Head trauma caused over half of injuries in 0-5 year olds (51.9%, n=121). Falls were common and increasingly prevalent in younger children, causing 56.6% (n=372) of injuries. In adolescents, penetrating violence caused more than one in five injuries (21.9%, n=50). Most injured children survived (99.8%, n=658). However, one in four (26.1%, n=172) had safeguarding concerns and a quarter of adolescents had police, third sector, or external agency involvement (23.2%, n=53).

• **Conclusions:** This study describes ~~changing demographics of~~ modern-day paediatric trauma and highlights the variance in injury patterns in young children and adolescents. Importantly it highlights differences in actual rates of injuries compared to those reported from current national registry data. We must understand real risks facing 21st century children to effectively safeguard future generations. The results provide an opportunity to reassess the current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

Introduction

Trauma remains the leading cause of death and morbidity for children and young people.(1) Historically, road related incidents were the greatest source of death and serious injury to children(1). Contemporary mechanisms of injury are evolving, with interpersonal violence(2,3) and falls(4,5) overtaking as the most common causes of injury in children. Effective safeguarding of children and young people requires an accurate understanding of contemporary risk, this is essential to underpin future injury prevention strategies, if the success of those reducing road related casualties is to be replicated(6). As mechanisms of injury in children evolve, the focus of injury prevention processes must also adapt. Accurate understanding of modern-day injury patterns is therefore essential to minimise risk and enhance child safety.

Falls, traditionally seen as a predominant cause of injury in the elderly, are now a leading mechanism in children.(4,5) Despite this, awareness of the burden of falls for children in the UK is limited(7), especially when compared to falls prevention strategies seen in older people. Falls frequently result in head injuries in children, the impact of which is subject to a growing body of evidence detailing the cognitive and socio-economic impacts of even mild traumatic brain injury in early years.(16)

Contemporary reports also reveal a rise in violence related injury in both young adult(2) and paediatric populations(8,9), however current violence reduction strategies focus mainly on young adults.(3,10) In 2018 a single centre study in London found a penetrating injury rate of 9.4% in under 16s(2). Yet in the same year, national trauma data suggested just 6% of injured children aged 16 or less suffered penetrating injuries in London.(11) These data may under-represent the true incidence of paediatric violence-related injury due to the volume of cases not currently meeting Trauma Audit Research Network (TARN) national registry inclusion criteria. Currently the contemporary risks, aetiology and demographics of paediatric injury is unknown. Accurate understanding of this is vital to ensure appropriately targeted, effective injury prevention strategies and safeguarding (11).

We aimed to characterise the incidence of trauma in children cared for within the London Major Trauma System (LMTS). The primary aim was to investigate the contemporary causes, risks and outcomes of injury for children in differing age cohorts. Secondly, we wished to evaluate safeguarding interventions associated with injured children.

Methods

A prospective paediatric trauma evaluation was carried out over a three-month period from February to April 2018. This time-frame was chosen for consistency with previous trauma service evaluations within our system.(12,13) The LMTS serves a wide geographical region(14). Four Major Trauma Centres (MTCs) care for severely injured children and young people, whilst 34 Trauma Units (TUs) manage the less severely injured and provide safe onwards transfer for those requiring MTC interventions (Supplementary item 1). All MTCs and TUs within the LMTS were invited to participate in the evaluation. Engagement was optimised through meetings with network leads and the pan-London Paediatric Trauma group. Each site registered the evaluation with local clinical audit teams and had a dedicated consultant clinical lead and data collectors. Anonymised data were collected by clinicians on children who met at least one of the following inclusion criteria:

- those who had a trauma team activation (Supplementary item 2);
- those who were admitted or transferred (to MTC or quaternary service) due to trauma;
- those who met NICE criteria for CT head due to trauma (to capture those not otherwise included in trauma team activation criteria).

In view of the frequency with which children with minor injuries present to emergency departments the inclusion criteria were defined to identify the most severely injured children. Those with isolated minor injuries not requiring admission to hospital, advanced imaging or activating the hospitals trauma team response were not included. Patients were also excluded if they were found to have had a non-trauma cause for presentation or if their age exceeded the hospital's definition of a child. Pre-hospital deaths were not included in this project. The definition of 'paediatric' varies across the system, therefore, to reflect real world practice a child was defined as birth-16 years or birth-18 years as per individual hospital determination. Due to a lack of consensus in the literature, the study group decided to define adolescence as ≥12 years of age.

A case report form was completed for each patient. Data were collected on age, gender, mechanism of injury, location of injury, and injuries per body region. The primary outcome was in hospital mortality, secondary outcome was safeguarding concerns raised. Safeguarding children is defined by the UK government as *"preventing harm to children's health or development, taking action to enable all children and young people to have the best outcomes, to protect children from abuse and maltreatment and to ensure children grow up with the provision of safe and effective care."*(12) Safeguarding concerns could be raised by any clinical team member to highlight children or young people who may be at risk of harm. All children with safeguarding concerns were discussed in local psycho-social meetings as per local hospital policies and multidisciplinary team decisions were made regarding onward referral to social services and/or health visitor. Involvement of police and third sector organisations (including injury support and violence reduction programmes) were also captured. Children were followed up until they were discharged from hospital.

Descriptive statistics were used to compare differences between age cohorts (0-5 years, 6-11 years, and ≥12 years). These cohorts reflect significant periods of child development: infancy, childhood, and adolescence. Continuous data are presented as medians with interquartile ranges. Categorical data are presented with percentages.

This project was conducted by clinical staff within each of the four trauma networks forming the LMTS and met the criteria of a service evaluation, therefore ethical approval was not required.

Results

During the three-month study period 665 children were identified within the 22 participating hospitals (all MTC's and 18 TU's). Six were excluded due to non-trauma causes or age exceeding the hospitals definition of a child, leaving 659 children included in the evaluation. Of these, ~~half~~ 52% were cared for in an MTC and nearly two thirds were male (64.6%) (Table 1). ~~Whilst~~ The median age was 8.9 years [Interquartile range: 3.75-13.96]. A bimodal distribution of age was identified, with

peaks of injury in the very young (0-2 years) and in adolescence (Figure 1A). The youngest cohort (0-5 years) was the largest (37%) followed by ≥12 years (35%) then those aged 6-11 years (28%) (Table 1).

Across the entire cohort, penetrating trauma accounted for 9.6% of injuries, however in adolescents, penetrating injury affected 1 in 5 (21.9%). The predominant blunt mechanism of injury was falls (56.5%). Road traffic collisions accounted for 12.6% of injuries. Over a quarter of injured children required an operative intervention (29.4%) and admission to intensive care was 3.3%. Mortality was ~~very low~~ (<1%), with one child dying in the youngest cohort (Table 1). ~~Similarly,~~ The median hospital length of stay for survivors was ~~short at a median of~~ one day (IQR 1-3).

Location of injury differed according to age (Figure 1B). In younger children aged 0-5 years, the majority were injured in their home (70.8%). Almost three quarters of these younger children suffered falls (74.7%), with more than half of this age group sustaining head injuries (51.9%) (Table 1). Conversely, adolescent injuries commonly occurred in the street and almost a quarter of this age group (22.8%) were injured through interpersonal violence. Once again head injuries predominated however abdomino-thoracic trauma was greatest in adolescents compared to other age groups (10% vs. <1%, Table 1). Polytrauma affected **approximately** a tenth of the cohort (11.4%) (Table 1).

Table 1: Demographics and injury characteristics of children and young people cared for in the London Major Trauma System February-April 2018

	All Children (n=659)	0-5 years (n=247)	6-12 years (n=184)	≥12 years (n=228)	p value
Male	426 (64.6)	145 (59.4)	114 (62.0)	167 (73.2)	0.540
Female	233 (35.4)	102 (40.6)	70 (38.0)	61 (26.8)	0.008
Mechanism of injury:					
Blunt	596 (90.4)	243 (98.3)	175 (95.1)	178 (78.1)	**<0.001**
Penetrating	63 (9.6)	4 (1.7)	9 (4.9)	50 (21.9)	**<0.001**
Fall	372 (56.5)	184 (74.7)	109 (59.2)	79 (34.6)	**<0.001**
RTC	83 (12.6)	13 (5.3)	35 (19)	36 (15.8)	**<0.001**
Assault (all)	63 (9.5)	6 (2.4)	5 (2.7)	52 (22.8)	**<0.001**
Assault blunt	22 (3.3)	6 (2.4)	4 (2.2)	12 (5.3)	0.133
Assault penetrating	41 (6.2)	0 (0)	1 (0.5)	40 (17.5)	**<0.001**
Other*	139 (21.1)	43 (17.5)	35 (19)	61 (26.7)	**0.034**
Location of Injury					
Home	241 (40.5)	167 (70.8)	44 (27.5)	31 (15.6)	**<0.001**
School	98 (16.5)	16 (2.5)	45 (28.1)	37 (18.6)	**<0.001**
Street	152 (25.5)	21 (8.9)	46 (28.8)	85 (42.7)	**<0.001**
Other~	102 (17.1)	32 (13.6)	25 (15.6)	46 (23.1)	**0.026**
Body region injured:					
Head	252 (39.6)	121 (51.9)	65 (36.1)	66 (29.5)	**<0.001**
Upper limb	133 (20.9)	47 (20.2)	51 (28.3)	35 (15.6)	**0.007**
Lower Limb	113 (17.7)	26 (11.2)	35 (19.4)	52 (23.2)	**0.002**
Abdomino-thoracic	25 (3.9)	1 (0.4)	1 (0.5)	23 (10.3)	**<0.001**
Pelvis	4 (1.7)	0 (0)	2 (1.1)	2 (0.9)	0.302
Spine	19 (8)	1 (0.4)	8 (4.4)	10 (4.5)	**0.002**
Soft tissue	26 (11)	17 (7.3)	2 (1.1)	7 (3.1)	**0.005**

Face	23 (9.7)	13 (5.6)	8 (4.4)	2 (0.9)	**0.021**
Polytrauma**	27 (11.4)	2 (0.8)	5 (2.8)	20 (9.9)	**<0.001**
Management:					
MTC level care	343 (52)	126 (51.0)	91 (49.5)	126 (55.3)	0.462
Required Surgery	194 (29.4)	50 (20.2)	72 (39.1)	72 (31.5)	**<0.001**
Intensive Care Admission	22 (3.3)	5 (2.0)	7 (3.8)	10 (4.4)	0.329

All data are presented as n(%).
RTC: Road Traffic Collision, *Other includes sports injury, burns, deliberate self-harm. ~Other includes parks/recreation facilities/playgrounds, sports grounds, soft play locations. MTC: Major Trauma Centre. MTC level care: Any child or young person taken directly to or transferred to an MTC. Polytrauma: Two or more body regions injured.
Denominator changes where data was missing: Mechanism of injury: n=658 (blunt vs penetrating n=659), 0-5yrs n=246. Location of injury: all n=595, 0-5yrs n=236, 6-12yrs n=160, 12+yrs n=199. Body region injured: all n=637, 0-5yrs n=233, 6-12yrs n=180, 12+yrs n=224.

Safeguarding concerns were raised in 1 in 4 injured children (26.1%) (Table 2). These were identified in all age groups but bimodal peaks of concern were observed in the youngest (30.3%) and oldest children (33.3%) (Figure 2A). Overall, almost 1 in 3 children (30.6%) were referred to social services or the health visitor following their injury (Table 2) with similar bimodal peaks (Figure 2B). **49 (19.8%) children in the 0-5 years cohort were under 1 year old,** ~~A fifth (49, 19.8%) of children in the 0-5 years cohort were under 1 year old,~~ of these 45% (22) had safeguarding concerns and 63% (31) were referred for social services or health visitor input (Figures 2A and 2B). Almost a quarter of adolescents required input from the police and third sector organisations (Table 2) with a stepwise increase observed from age 13 years onwards.

Table 2: Outcomes

	All Children (n=659)	0-5 years (n=247)	6-12 years (n=184)	≥12 years (n=228)	p value
Mortality	1 (0.15)	1 (0.4)	0 (0)	0 (0)	0.434
Safeguarding concern	172 (26.1)	75 (30.4)	21 (11.4)	76 (33.3)	**<0.001**
Referral to HV/SS	202 (30.6)	97 (39.3)	30 (16.3)	75 (32.9)	**<0.001**
Police Involvement	84 (12.7)	13 (5.3)	18 (9.8)	53 (23.2)	**<0.001**
3rd Sector/external agency involvement	61 (9.3)	4 (1.6)	4 (2.2)	53 (23.2)	**<0.001**
Hospital stay (days)~	1 (1-3)	1.5 (1-2)	1 (1-4.5)	2 (1-5)	**<0.001**

All data are presented as n(%) except for Hospital Stay (Median with Interquartile range)~. HV: Health Visitor; SS: Social Services.

Discussion

This project has characterised the contemporary incidence and mode of traumatic injury for children and young people within the LMTS through a prospective evaluation of those presenting to a trauma system not selected by Injury Severity Score (ISS) or length of stay. This includes data captured for all children and young people presenting with an injury or mechanism severe enough to require trauma team activation, admission or transfer for ongoing care, and/or CT head. This data offers a contemporary overview of paediatric trauma within a region and helps to fill existing knowledge gaps present due to the current national registry inclusion criteria. Data were captured from children

and young people managed in both MTC and TU settings, including both rural and inner-city populations using the same core methodology as previous trauma service evaluations.(13,14)

Variation exists in the pattern of injuries seen in childhood and adolescence. Differences were seen in the location of injuries, with preschool age children most likely to be injured in their homes compared to older children and adolescents, who were most likely to be injured in the street. Traditional mechanisms of trauma associated with children **and young people**, such as road traffic collisions, were less evident, with falls the primary cause of injury in the younger cohort whilst a demonstrable rise in interpersonal violence and penetrating injuries was observed in adolescence. Head injuries predominated across all age groups with over half of the younger children affected. The higher rate of abdomino-thoracic injuries seen in adolescents is thought to be associated with increased penetrating trauma in this group (Supplementary table 1). A quarter of the children **and young people** included in this evaluation had significant safeguarding concerns raised and one in four adolescents required input from police and/or third sector organisations. Mortality was low (0.2%) contrasting with previous reports of 8.8% in severely injured(14) and 3.1% in moderately injured children and we are unable to account for this.(5) Deaths may have occurred at scene, not captured by this project. Our cohort contained children **and young people** of all injury severities and was not limited by TARN inclusion criteria, **other** factors such as the maturation of the trauma system may have contributed to increased survival.(13)

This study highlights differences in how children and adolescents sustain traumatic injury. In our cohort, the predominant cause of injury in children **and young people** was falling. This was greater in younger children, a group most at risk of injury in their home environment. Injury in the home is common and offers opportunity for injury prevention.(15) Children aged 0-5 years were most likely to suffer head injuries. Previous reports have suggested toddlers, aged 1-4 years, have the lowest rates of head injury, however such reports have limited their data to moderate to severe injury.(5) By expanding our cohort, we highlight the risk of head injuries in this age group, most sustained as the result of accidental falls. The consequences of falls in this age group, particularly those with mild traumatic brain injury, are increasingly appreciated, with evidence suggesting lasting cognitive effects for the individual and economic effects for society.(16) Understanding the true burden and the avoidable nature of these injuries makes head injury prevention a paediatric public health priority.

Interpersonal violence poses a serious risk to adolescents(2)(8) with one fifth sustaining injuries due to alleged assault, the vast majority of which were penetrating. This equates to one child every two days suffering penetrating injuries across our region. Reported rates of paediatric penetrating injuries have previously been much lower, 2.2%.(5) Our findings highlight how current TARN eligibility criteria may underestimate the reality of paediatric penetrating injury ~~nationally~~ as many will stay in hospital for less than three days or not require critical care admission. Accurate understanding of the true volume of these injuries is vital if we are to effectively target resources for injury prevention. Prevention strategies must recognise the involvement of younger children and capitalise on the potential for intervention in this group to break the cycle of children later presenting as young adults with life threatening injuries.

Safeguarding remains a major concern in contemporary paediatric trauma care. The need for safeguarding was raised in a quarter of cases and this was highest in both the youngest group and adolescents. It is known infants under one year are at the highest risk of non-accidental injury

(NAI).(17) Educational programmes introduced to aid parents to develop coping strategies for crying babies have been highlighted as important in reducing the risk of these youngest and most vulnerable children.(18-20) The bimodal distribution of safeguarding concerns also highlights the need to consider the unique safeguarding challenges faced by adolescents(21). Our findings question what effective modern day safeguarding in children and adolescents looks like. Safeguarding children **and young people** has traditionally been viewed as a family experience, with support for caregivers being of paramount importance in preventing harm to children. The same view is not currently taken for children or adolescents as the victims of interpersonal violence. Historically effort has focused on the prevention and identification of NAI, often at the hands of caregivers.(22) Yet safeguarding practices must also reflect the contemporary risks of intentional interpersonal violence and the prevention of avoidable harm from unintentional injury which may impact a child's ability to reach their full potential. Early years interventions may be vital in reducing these risks(23).

Limitations exist in this project. Firstly, some of the smaller TUs were unable to participate due to service commitments therefore cases will have been missed. However, each of the four major trauma centres participated, suggesting that the most severely injured children were included. **Our definition of adolescents and the varying upper age limit may not reflect paediatric practice elsewhere, however this illustrates the real world variation seen across different settings.** Although the LMTS serves both urban and rural populations, we acknowledge these findings may not be representative of all trauma networks. **The high proportion of penetrating injuries seen in our cohort may not currently represent the entire UK however with the rising incidence of violence and county lines safeguarding issues, it is essential to raise awareness of this and the need for prevention.** The project ran for a period of three months, the time frame chosen in line with previous trauma service evaluations, therefore seasonal differences in attendance may not be accounted for. ISS were not collected for all included children therefore overall analysis of injury severity was not possible. **This may also affect mortality comparisons, however only one child died during our study period.** Some physician or institutional variations may exist between hospitals however LMTS has paediatric trauma guidelines which promote standardisation across the units. Finally, children whose injuries or mechanism were not severe enough to meet the inclusion criteria were not included, incorporation of these may have identified other patterns of injury which may yield further opportunities for injury prevention.

By expanding our lens, this evaluation has bridged a gap in understanding paediatric trauma, however many learning opportunities remain. Further research would ideally include a yearlong, national study, removing seasonal and geographical variation, to include data capture on pre-hospital deaths, emergency department discharges and longer-term outcomes.

Finally, injured children should not be thought of in isolation. Consideration must be given to the families and wider support networks which play a vital role in prevention and in rehabilitation. As such, opportunities for patient and family engagement in future work and co-development of injury prevention strategies must be at the forefront.

Conclusion

This evaluation has described the changing demographics of contemporary paediatric trauma and has highlighted the variance in injury patterns in young children and adolescents. Importantly it has

highlighted differences in actual rates of injuries compared to those levels reported from current national registry data. The importance of a contemporary understanding of the real risks facing children in the 21st century cannot be underestimated if we are to safeguard our future generations effectively. The results provide an opportunity to reassess our current approach to injury prevention, child and adolescent safeguarding, and public health campaigns for child safety.

What is known about this subject?

- Trauma is the leading cause of death in children
- Injury patterns vary across age groups
- Falls are the most common cause of injuries in under 5's

What does this work add?

- National registry criteria vastly underrepresents the true volume of paediatric trauma
- Prevalence of interpersonal violence in children and adolescents is significantly higher than previously reported
- Traditional approaches to safeguarding must be modernised to reflect contemporary risks of interpersonal violence and avoidable harm

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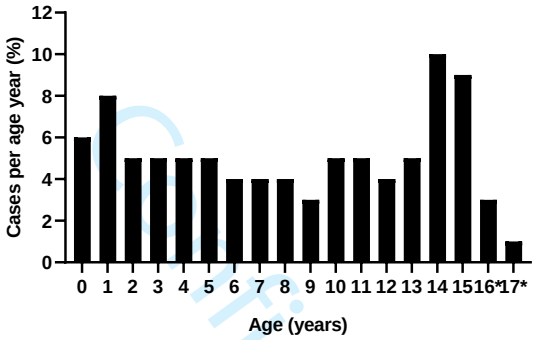
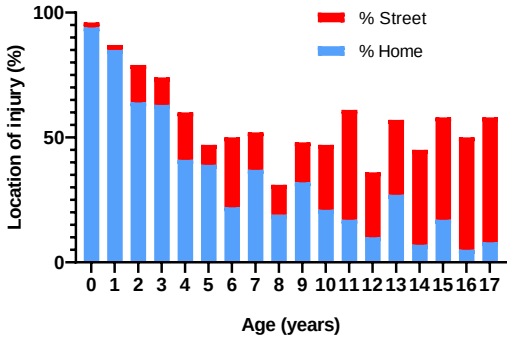
Figure 1

A



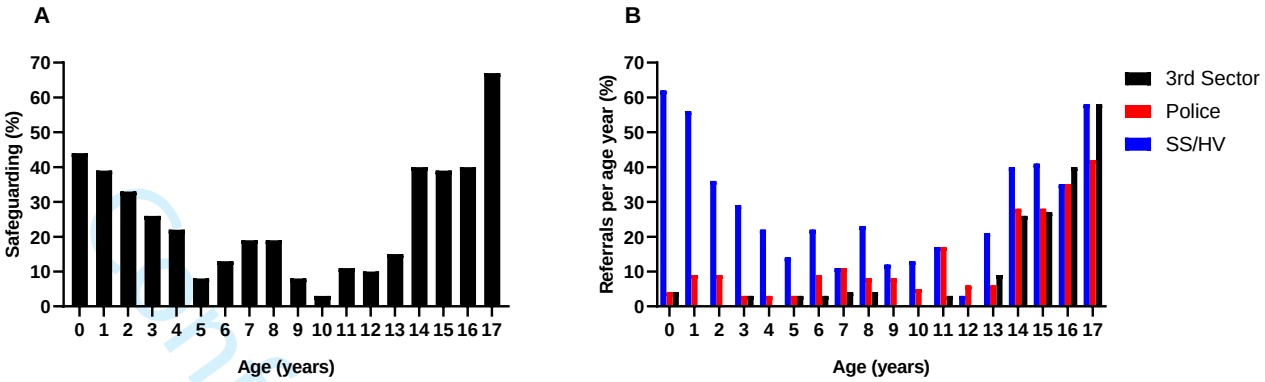
B



A. Bar graph shows the percentage of cases per age in years. (*16/17 year-olds classified as paediatric in 2/22 hospitals)

B. Stacked bar graph shows the proportion of children injured at home or in the street per age in years.

Figure 2



A. Bar graph shows the proportion of safeguarding referrals made per age in years.

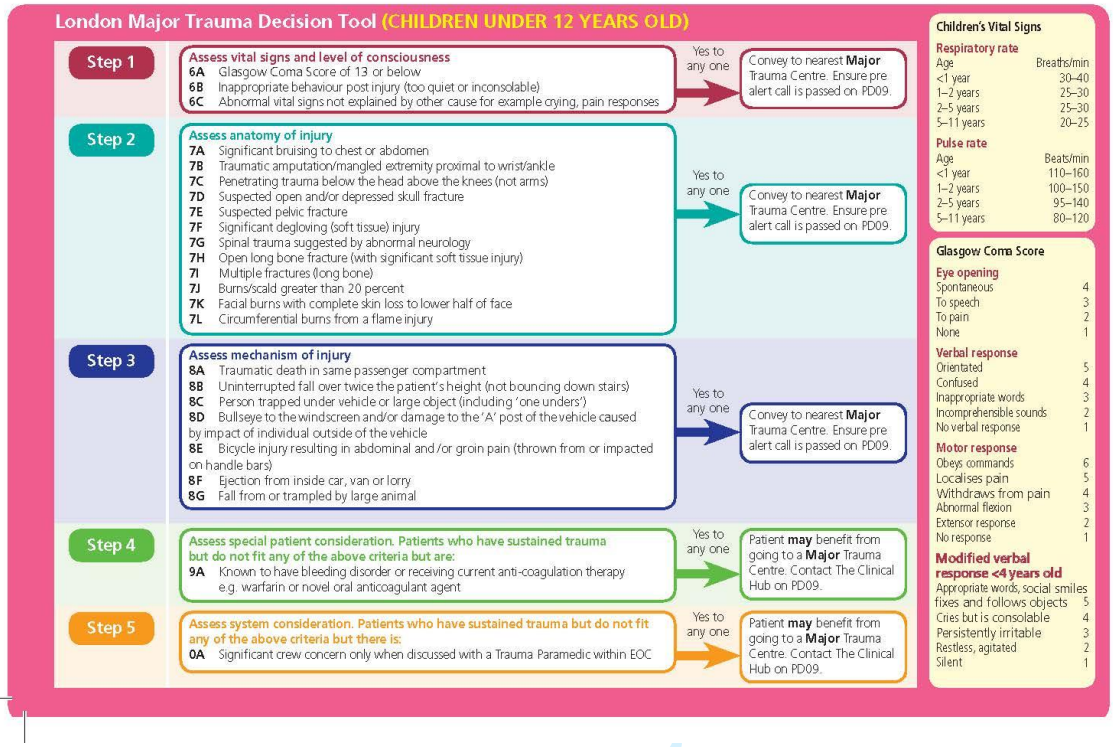
B. Bar graph shows the referrals to social services/health visitor and involvement of police and 3rd sector organisations per age in years.

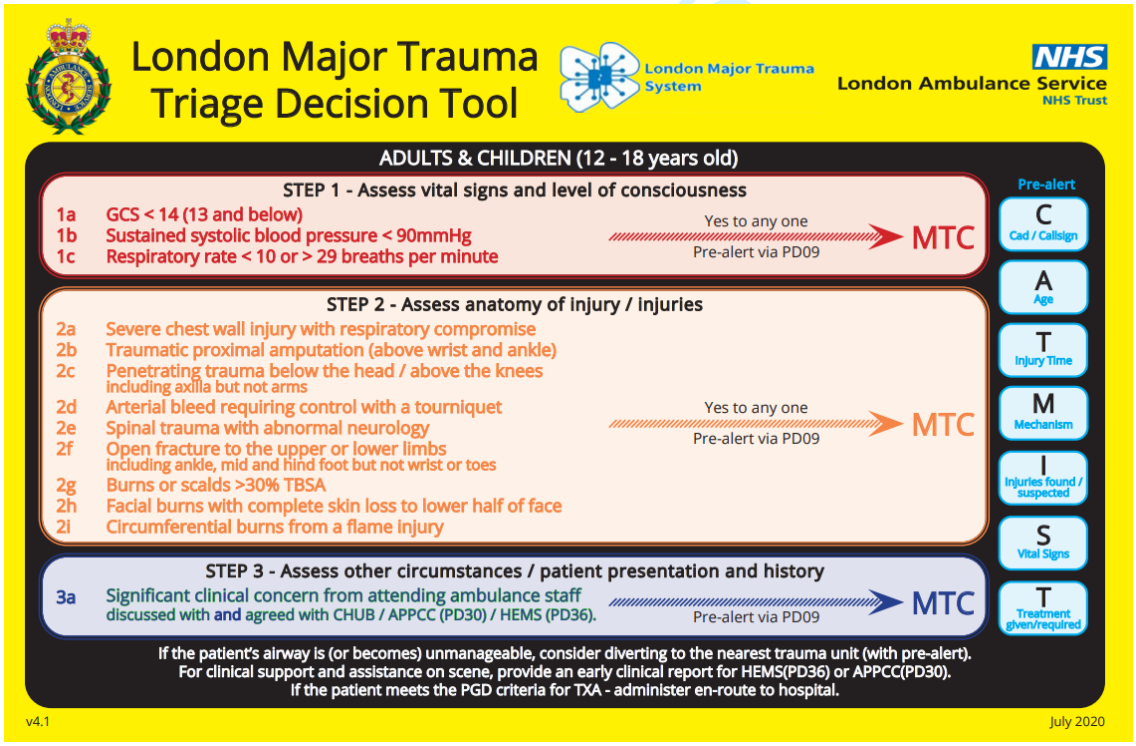
Supplemental Table 1: Body Region Injured

	Blunt Mechanism (n=596*)	Penetrating Mechanism (n=63~)
Head	252 (42.3)	0 (0)
Upper limb	126 (21.1)	7 (11.1)
Lower Limb	93 (15.6)	20 (31.7)
Thoraco-abdominal	10 (1.7)	15 (23.8)
Pelvis	4 (0.7)	0 (0)
Spine	19 (3.2)	0 (0)
Soft tissue	20 (3.4)	6 (9.5)
Face	20 (3.4)	3 (4.8)
Polytrauma	16 (2.7)	11 (17.5)

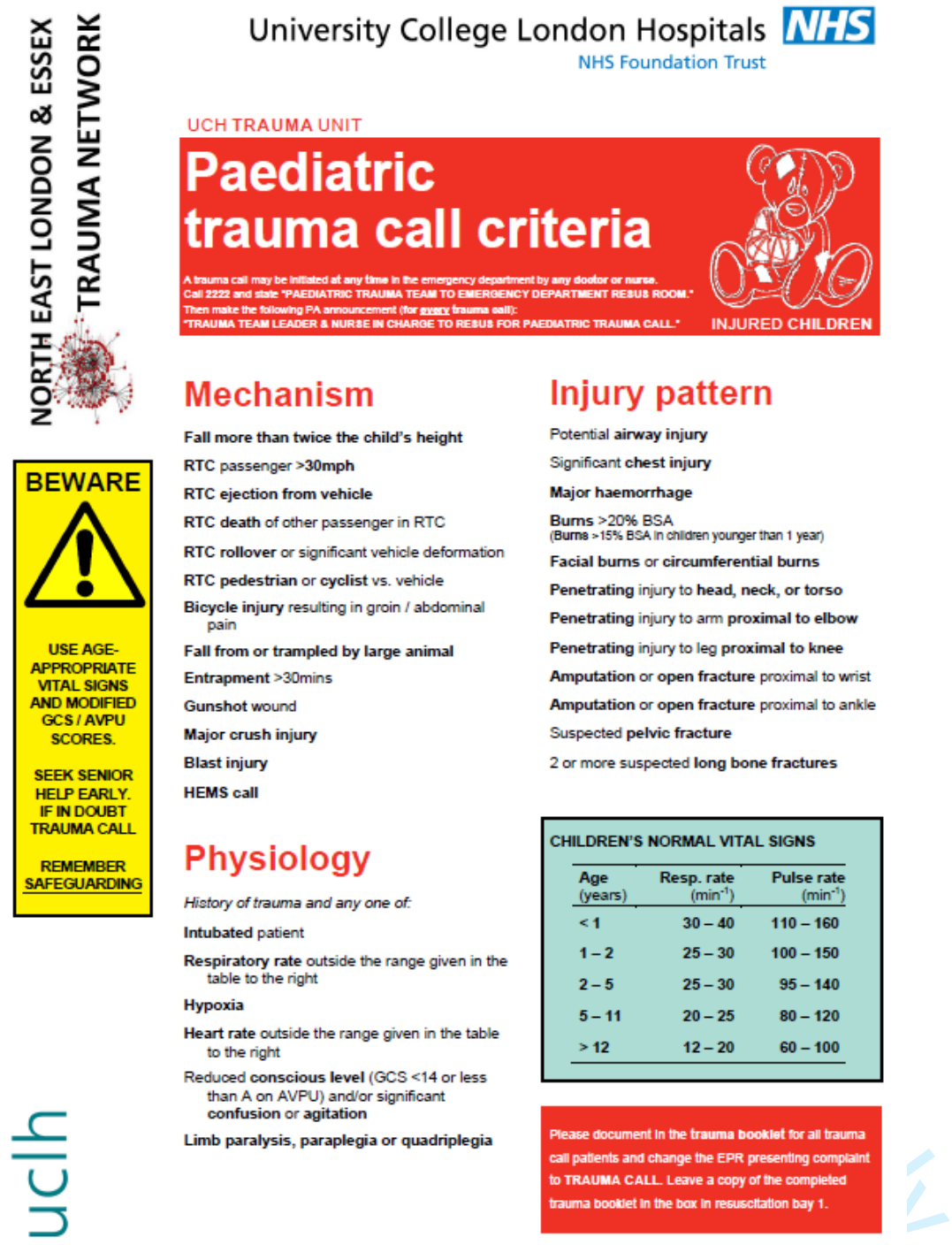
*15 cases with significant mechanism of injury but no injury identified, 21 cases body region injured not documented. ~1 case body region not recorded.

Supplementary item 1: Example of a pre-hospital care trauma triage tool to determine where children and young adults with trauma will be transported for care. (Available at https://www.c4ts.qmul.ac.uk/london-trauma-system/clinical-policies-and-documents (Accessed June 2021)





Supplementary Item 2: Example of a local trauma team activation policy (Reference: UCLH Trauma Operational Policy, January 2019)



NORTH EAST LONDON & ESSEX TRAUMA NETWORK

University College London Hospitals NHS
NHS Foundation Trust

UCH TRAUMA UNIT

Paediatric trauma call criteria

A trauma call may be initiated at any time in the emergency department by any doctor or nurse.
Call 2222 and state "PAEDIATRIC TRAUMA TEAM TO EMERGENCY DEPARTMENT RESUS ROOM."
Then make the following PA announcement (for every trauma call):
"TRAUMA TEAM LEADER & NURSE IN CHARGE TO RESUS FOR PAEDIATRIC TRAUMA CALL."

INJURED CHILDREN

BEWARE

USE AGE-APPROPRIATE VITAL SIGNS AND MODIFIED GCS / AVPU SCORES.

SEEK SENIOR HELP EARLY. IF IN DOUBT TRAUMA CALL

REMEMBER SAFEGUARDING

Mechanism

Fall more than twice the child's height

RTC passenger **>30mph**

RTC ejection from vehicle

RTC death of other passenger in RTC

RTC rollover or significant vehicle deformation

RTC pedestrian or **cyclist** vs. vehicle

Bicycle injury resulting in groin / abdominal pain

Fall from or trampled by large animal

Entrapment >30mins

Gunshot wound

Major crush injury

Blast injury

HEMS call

Physiology

History of trauma and any one of:

Intubated patient

Respiratory rate outside the range given in the table to the right

Hypoxia

Heart rate outside the range given in the table to the right

Reduced **conscious level** (GCS <14 or less than A on AVPU) and/or significant **confusion** or **agitation**

Limb paralysis, paraplegia or quadriplegia

Injury pattern

Potential **airway injury**

Significant **chest injury**

Major haemorrhage

Burns >20% BSA
(**Burns** >15% BSA in children younger than 1 year)

Facial burns or **circumferential burns**

Penetrating injury to **head, neck, or torso**

Penetrating injury to arm **proximal to elbow**

Penetrating injury to leg **proximal to knee**

Amputation or **open fracture** proximal to wrist

Amputation or **open fracture** proximal to ankle

Suspected **pelvic fracture**

2 or more suspected **long bone fractures**

CHILDREN'S NORMAL VITAL SIGNS

Age (years)	Resp. rate (min^{-1})	Pulse rate (min^{-1})
< 1	30 – 40	110 – 160
1 – 2	25 – 30	100 – 150
2 – 5	25 – 30	95 – 140
5 – 11	20 – 25	80 – 120
> 12	12 – 20	60 – 100

Please document in the **trauma booklet** for all trauma call patients and change the EPR presenting complaint to **TRAUMA CALL**. Leave a copy of the completed trauma booklet in the box in resuscitation bay 1.

uclh